INDUSTRIAL RESEARCH

FEBRUARY - MARCH 1960

one dollar

disposable clothing—page 37

PROFITABLE APPLICATIONS FOR CREATIVE MANAGEMENT

FEB-MAR 1960

RE

FOR YEARS, *food advertisers have attempted to combine sex with food; tire manufacturers have tried to get sex into tires, etc. This issue's cover scores a new first: sex into research.*

If it's true that the function of a magazine cover is to induce the reader to look at it and inside the publication, then it all may be worth it.

On the serious side, the not-very-sexy abstract nude shedding her clothing, also abstractly, serves to illustrate a series of important research projects on disposable and nonwoven clothing and other fabrics. The article beginning on page 37 summarizes the current state of the art in this field.

The entire article is printed on a special stretchable paper that may have application in disposable fabrics.

(Cover photographed for I•R by George Pickow, Three Lions.)

Upcoming

New Uses for Ultrasonics

Thermocatalytic Combustion

Why Don't We Protect Our Inventors?

Microminiature Components

Picture Portfolio: Argonne National Laboratory

Special Section: Energy

Industrial Research magazine is published to help management men and engineers keep informed of the profitable applications of research in all fields of industry. Its goal is to help place research on a par with other management functions, such as sales, finance, production, and engineering, and—by doing this—to help reduce the time lag between invention and production.

INDUSTRIAL RESEARCH
200 S. MICHIGAN AVENUE • CHICAGO 4

the new bimonthly management magazine

Subscriptions: $5 for one year; $9 for two years; $13 for three years, to United States, its possessions, and Canada; $1 extra for each six issues to foreign countries. Foreign remittance by International Money Order payable at Chicago, Ill., U.S.A. When changing address, please notify Circulation Dept. at address above. As I • R is a management magazine, changes of job title are important and notification is appreciated.

Advertising: I • R accepts 1, 2, 3, and 4-color ads, either offset or letterpress. Inserts, special paper stocks, die-cuts are available. Rate and data card showing complete closing date schedule, special colors, and frequency and bulk rates, is available to advertisers and agencies. Telephone: HArrison 7-1794, Chicago; address above.

Editorial: Professional science writers, industrial executives, research workers, educators, artists, and photographers are invited to query the editor at address above, with ideas for articles or art. Do not send manuscripts without query. Answers to queries are prompt.

INDUSTRIAL RESEARCH

FEB-MAR 1960

FOR R&D MEN, CREATIVE ENGINEERS, AND TECHNICAL DIRECTORS

VOLUME TWO, NUMBER ONE

5

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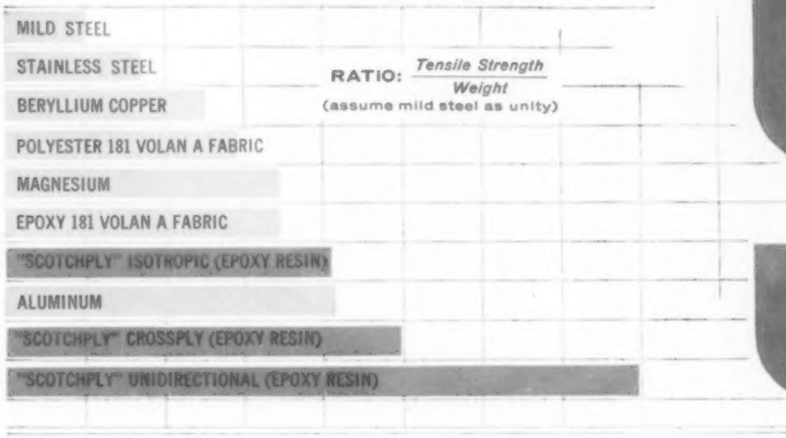
STATE-OF-THE-ART ARTICLES

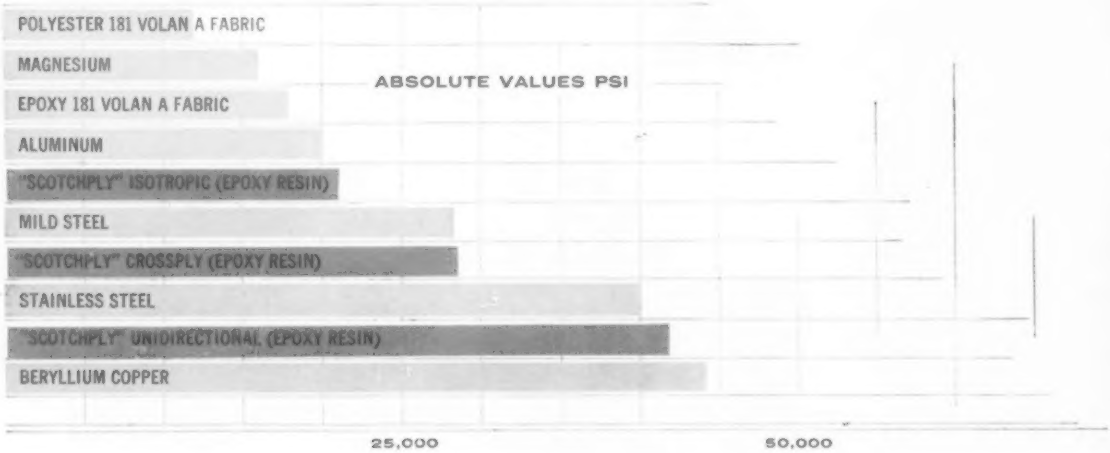
DEPARTMENTS

Sc

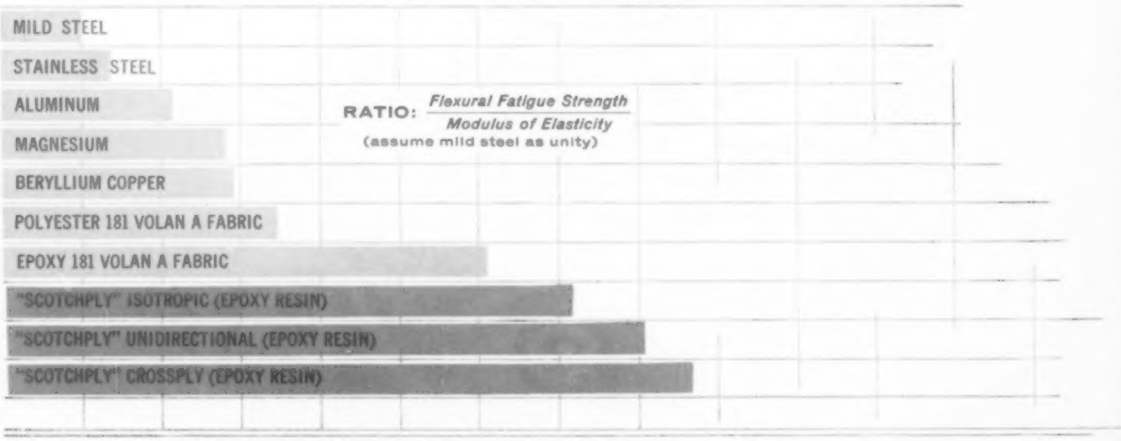
Tensile strength-weight ratios



Flexural-fatigue strength @ 2 x 10^6 cycles



Allowable flexural-fatigue deflection @ 2 x 10^6 cycles



I R

LETTERS TO THE EDITOR

Saving the RRs

Sir:
Your "Can Research Save the Railroads?" article was, with the exception of the title, a good article. The title implied technological backwardness of the industry — an implication which the article doesn't support. It might have been better labeled "Can Research Alone Save the Railroads?"

The problems of constructing atomic locomotives are great, but not insurmountable. And small atomic power plants every 10 or 15 miles along a right-of-way would make possible economic electrification — ultimately the key to practical electrification.

Your magazine gives good promise of filling a sizeable void.

John D. Mitros
Illinois Central Railroad

Sir:
Certainly enormous research and testing expenditures have paid off in terms of competitive operation, as you point out in your article, "Can Research Save the Railroads?"

However, research alone is not enough. Unions must be curtailed, government must become somewhat more laissez-fair, and management must be allowed, once again, to manage.

Your reporting of these problems, in addition to pointing out technical improvements in railroading, is a unique, long-awaited step in technical publishing.

George Barrington
Research Consultant
Assn. of Amer. Railroads

Military R & D

Sir:
Gen. Trudeau is ridiculous if he expects to shorten lead time from research to production ("Military R&D" column) without first reorganizing both government and industry technical recruitment practices and taking it out of the hands of inept, inane personnel managers who can no more hire a PhD than you or I could fly to the moon unaided.

One of the more serious problems facing our technical future is that of getting engineers into jobs which will make the most of their talents. Engineer job-switching is rampant, not because of discontent or greener grass across the street, but because many engineers were recruited improperly in the first place.

(name withheld by request)

Opinions on 4th Issue

Sir:
The Nov-Dec issue of *Industrial Research* was my first contact with this challenging magazine. The feature section on space technology was most appropriate for an introduction to the '60s.

You are to be congratulated as to your objectives and manner of presentation. The future of this country lies in the minds of people—in the ideas yet unborn and in the engineering fulfillment of them.

Any contribution to this end is a most worthwhile objective.

N. G. Bittermann
Technical Director
Deputy Commander, Tests
Air Force Missile
Test Center
Patrick Air Force Base, Fla.

Sir:
I believe you really have something in *Industrial Research*. The general feeling here is that it is a good thing, though some of us wonder if you are going to be able to continue with such a wide variety of very high-level papers.

Unfortunately, the meat of the publication is pretty well cluttered up with advertising. I realize that this advertising is the bulk of the financial support of the publication, but it does present a distinct nuisance value. However, this is only my own personal attitude.

Richard E. Borup
Head, Analytical Division
Cities Service R&D Co. Inc.

Sir:
A copy of your first issue has come into my possession and I have become so fascinated I would like to buy the other back copies.

I am a securities broker and am primarily interested in new developments which you highlight.

I salute your fine job of explanation.

Henry O. Haughton Jr.
Pelham, N.Y.

Sir:
You have done a tremendous job with *Industrial Research* and I greatly enjoy reading it

Clyde Williams
President
Clyde Williams & Co.

Sir:
We read with considerable interest the article, "The World's Hottest Alloys," by Harry B. Goodwin. I would like to get a copy of the tantalum capacitor testing device photograph; this is a beautiful shot and an interesting application.

Advertising Manager
Andrew J. Yiannias
Thermo Electric Mfg. Co.

Sir:
Your periodical represents a distinct presentation of material often novel in approach. It is for this reason that I look forward to receiving it each issue.

George D. Bieber
Needham, Mass.

continued on page 10

5 Notes about the fifth issue

A series of technical problems involved in the change-over from quarterly to bimonthly publication and from side-wire to patent binding (you'll notice the magazine now will "lay flat" when opened) combined to make this issue the February-March issue. As originally planned, I•R will publish six times this year: Feb-Mar, Apr-May, June-July, Aug-Sept, Oct-Nov, and Dec-Jan.

■

Our experiment in the last three issues with a combination subscription-reader inquiry card keyed to advertisements revealed: most readers who responded to an ad did it directly, that is, by writing a letter instead of using the card (indicating most I•R readers have secretaries for such chores); the average number of ad inquiries circled was two per card; only 38% of cards received requested ad information, the majority being used for new or renewal subscriptions or for free article reprints.

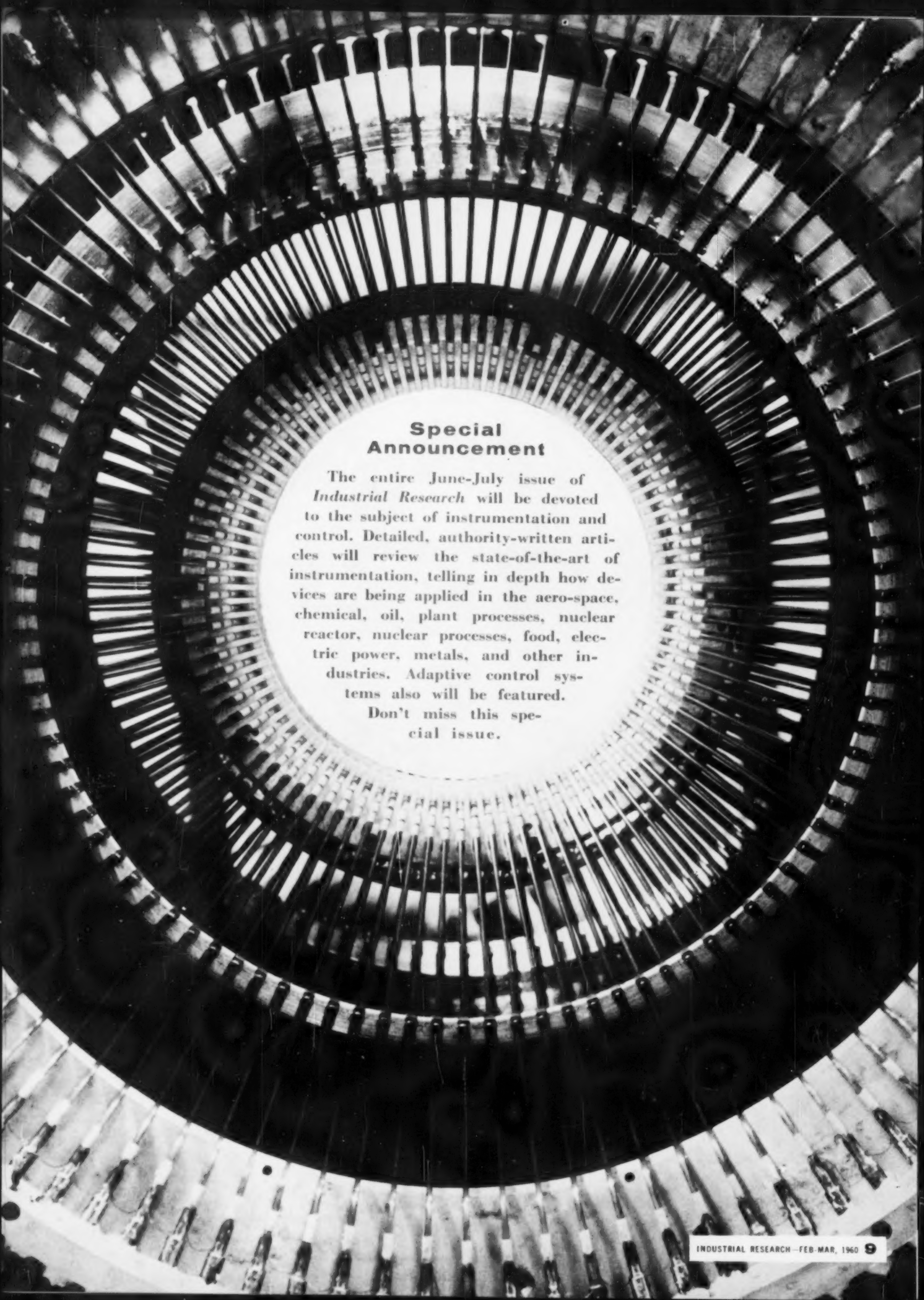
Thus, since most of you prefer writing letters to circling numbers on a postcard, we've dropped the "bingo card." In its place this issue is a new, easier-to-use postcard exclusively for free reprints, new subscriptions, and renewals.

Any suggestions?

■

A group of marketing professors and students from Roosevelt

continued on page 10



Special Announcement

The entire June-July issue of *Industrial Research* will be devoted to the subject of instrumentation and control. Detailed, authority-written articles will review the state-of-the-art of instrumentation, telling in depth how devices are being applied in the aero-space, chemical, oil, plant processes, nuclear reactor, nuclear processes, food, electric power, metals, and other industries. Adaptive control systems also will be featured. Don't miss this special issue.

Sir:

I am very favorably impressed with your magazine and would like to congratulate you on it.

John E. Barkley
Director of Research
Mechanical Division
General Mills

Sir:

Since we all appreciate true compliments, I am offering one to you. For the first time in my life, I have spent my own money to subscribe to a technical publication and have it sent to my home.

R. H. Patchen
Production Engineer
Aerojet-General Corp.
Sacramento, Calif.

Sir:

Of all the technical and other subscriptions that I have, I value I•R above all. I only wish that more of the I•R type of interest and information were available in the various and related field publications.

Paul A. Hofer
Senior Technical Writer
Royer & Roger Inc.
New York City

Sir:

Your concept of bringing to bear all current scientific and applications information on a given subject—no matter what the field of science involved—is an exciting one.

It is, of course, the same idea that *Scientific American* and *Fortune* use. However, the former is non-industrial and the latter is non-technical. I•R seems to fill the need for an industrial magazine of the sciences.

Peter M. Gullford
Chief Engineer
The Orington Co.

Sir:

Industrial Research has just come to my attention, and I am enclosing my three-year subscription. This is a most impressive publication.

Hayse H. Black
Industrial Wastes Consultant
Dept. of Health, Education, & Welfare

University chose to poll I•R readers recently, along with a dozen other businesses, old and new. Probably the most astounding revelation was not what *you said, but how many of you said it. Sixty-two per cent of readers polled responded!*

This compares to an average response of other polls of 18%.

Here's what you said: I•R is the most useful to you of the six magazines listed (our competitors); 63% have mentioned the magazine to their associates (for which we thank you); the great majority receive 10 magazines regularly; more than 50% spend more than one hour reading I•R, mostly at home. (A detailed analysis of the survey will be sent on request.)

■

Uncredited "futuristic" illustrations in the Space Technology special section, Nov-Dec issue were commissioned by American Bosch Arma Corp. Illustration of the proposed satellite communications station was furnished by RCA.

Since this ad first appeared on June 16th 1959 43 engineers have joined HMED — and there are approx. 38 positions at all levels open now!

412 L EXPEDITE

ENGINEERS • SCIENTISTS

General Electric's Heavy Military Electronics Dept.

AWARDED CONTRACT FOR

Systems Integration, Engineering, and Management of...

AIR WEAPONS CONTROL SYSTEM 412L

A universal electronic control system to meet the vast problem of Air Defense outside of the Continental United States.

Systems-oriented engineers and scientists will appreciate the broadband technical challenge of the Air Weapons Control System 412L. There are important openings for men who are experienced in: Weapons Systems Analysis • Mathematical Analysis of Engineering Problems • Computer Programming • Military Communication Systems • Radar Systems • Weapons Control Systems • Electronic Circuitry • Industrial & Military Psychology

● Working in close cooperation with the USAF, it is Heavy Military's responsibility to integrate all subsystems—data acquisition, communications, data processing and display—plus various defensive weapons into a well coordinated and efficient operating system.

VERSATILE AIR CONTROL APPLICATIONS The revolutionary 412L can be used to defend a single airfield, or, by linking control sites together, it could be used in a limited action to provide air control for an area the size of Alaska. Similarly, by linking the capabilities of countries together, a system could be provided for the air control of an entire continent. Designed for *both* fixed and mobile applications, the 412L will be used primarily outside the U. S. since the SAGE system is used for the defense of this country.

HMED IS ALSO DESIGNING THE "HEART" OF THE SYSTEM
In addition to its prime mission of providing systems management, HMED will design, develop and produce the data processing and display subsystem which is the "heart" of the 412L. Capable of rapidly and automatically detecting and tracking air targets, the subsystem operates without human assistance, except under unusual circumstances.

OTHER FAR-RANGING PROGRAMS AT HEAVY MILITARY

At the present time additional far-ranging programs are being pursued in diverse and important areas at HMED:

- Fixed & Mobile Radar
- Shipborne Radar
- Underwater Detection Systems
- Missile Guidance
- Data Handling Systems
- Communications

Individuals with experience in systems analysis or specific equipment design in the areas listed above are invited to forward their resume in complete confidence to Mr. George Callender, Div. 135-MM

Write today or call me collect at GR 6-4411, Ext. 7830
George Callender

HEAVY MILITARY ELECTRONICS DEPARTMENT
GENERAL ELECTRIC
Court Street, Syracuse, N.Y.

EXPECT IN 1960:

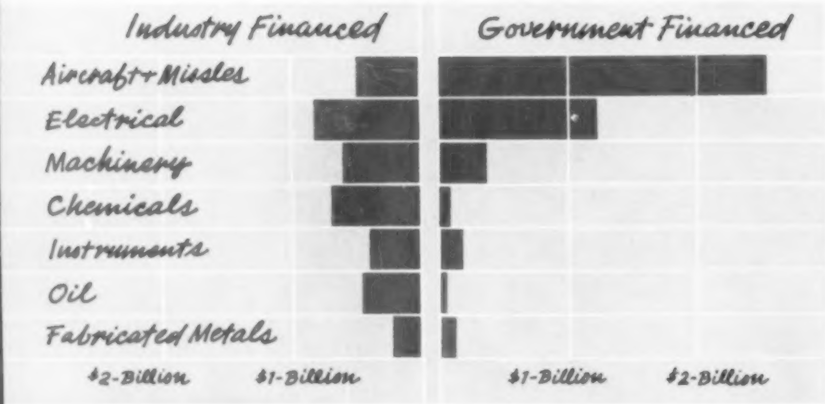
- *Practical MHD power.*
- *Dramatic advances toward controlling thermonuclear power.*
- *A Russian soft landing on the moon, possibly manned.*
- *A U.S. unmanned moon landing.*
- *An American in orbit.*
- *Space probes to Mars, Venus, and the sun.*
- *The first private aircars.*
- *Throwaway modular electronic equipment.*
- *Smaller circuits utilizing molectronic principles.*
- *Computers 1,000 times faster than present ones.*
- *Better fuel cells in more applications.*
- *New anti-radiation drugs.*
- *Stronger plastics and rubber, and new synthetics.*
- *Stronger steel alloys.*
- *Gas-lubricated bearings operable at very high and very low temperatures.*
- *Bigger cans of food.*
- *Indefinite storage of whole blood by freezing.*

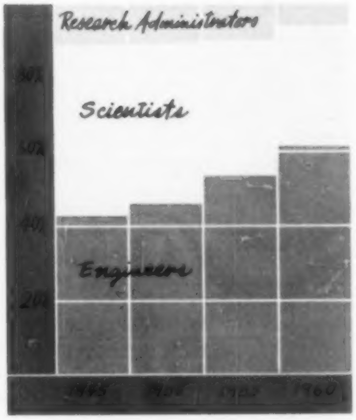
DON'T EXPECT:

- *More money to be spent on basic research; emphasis will be placed on hardware.*
- *Controlled thermonuclear power.*
- *A U.S. nuclear airplane.*
- *The much-publicized atom-blasted harbor in Alaska.*
- *Large aircars for rapid transit.*
- *Practical photoelectric power.*
- *A practical gas turbine engine for automobiles.*
- *Fuel cells to replace the internal combustion engine.*
- *Replacement of blast furnaces by direct ore reduction.*
- *Irradiated foods in grocery stores.*

by **S. David Pursglove,** *I-R Washington correspondent, and the staff of Industrial Research*

THE I-R 1960 FORECAST: $13-BILLION





FINANCIAL BURDEN *for 1960's giant research expenditure shows government-business share varies greatly by industry (left). Center chart reflects short-sighted manpower policies that continue to emphasize applied over basic science. At right, the research dollar is split into its four unequal segments.*

ASTRONAUT *climbs into space capsule designed by McDonnell Aircraft Corp. to orbit first American in 1960.*

FOR RESEARCH

THE UNITED STATES—its government, industries, schools, and institutions—will spend more money on research and development this year than it did in 1959. However, it will be only a little more, and will not reach the goals optimistically set earlier.

The outlay this year—slightly more than $13-billion, up from just under $12-billion in 1959.

Government agencies, companies, and trade associations told *Industrial Research* the figure will be up about 12%. They cannot be sure, however, until they know:

How badly did the steel strike affect sales upon which many R&D budgets are based?

To what extent will current Russian achievements affect government planning?

Will money needed for R&D become tighter or easier in the financial markets?

What will the fiscal 1961 federal budget, which affects the last half of this year, look like?

1. *research budgets*

In spite of industry and government both giving lip service to the need for more basic work, most firms expect to see *less* money spent on basic research this year, for two reasons: Congress wants to see some items on the shelf instead of in the idea book; and the feeling that it takes more than just money to make fundamental scientific progress.

The attitude of Congress is especially important to research leaders. Congress this year will appropriate just over half of all the research money to be spent in or for the United States. In 1956, the federal government appropriated $3.1-billion of the $6.4-billion spent on R&D by industry. The latest official figures (National Science Foundation) are for 1957, when the government provided 52% ($3.7-billion) of the R&D money used by industry. The federal outlay is climbing, but even if the government's share of R&D funds should remain the same, here is how the money will be spent this year:

- Industrial R&D financed by government...$4.9-billion
- Industrial R&D financed by industry...... 4.8 "
- Government in-house R&D.............. 2.0 "
- Universities and institutions .... 1.5 "

The government's unequal support

The percentage for government-financed R&D in industry is misleading. The government will supply well over half of the total funds that all U.S. industry will spend on R&D in 1960. However, this does not mean that the government is subsidizing *each industry* to that extent. For example, federal money accounts for a little less than 9% of all the R&D money to be spent by the chemical industry, but the total amount to be spent is only $700-million. On the other hand, the government will contribute 85% of R&D money to be spent by the aerospace industries. And that is 85% of a huge $3-billion.

Industry will spend its own and government's $9.7-billion R&D budget this year in the following proportion:

INDUSTRY (GOVERNMENT SHARE)	DOLLARS (MILLIONS)
Aircraft, missiles, parts (85%)	$3,000
Electrical, non-missile electronics (61%)	2,000
Machinery (non-electrical) (38%)	910
Chemicals and allied products (9%)	700

Professional and scientific instruments (30%)	445
Petroleum products and extraction (4%)	370
Fabricated metal products and ordnance (40%)	265
Telecommunications and broadcasting (55%)	250
Primary metals (gov't share unknown)	125
Rubber products (gov't share unknown)	115
Food and kindred products (gov't share unknown)	108
Stone, clay, and glass products (1%)	98
Paper and allied products (gov't share unknown)	63
All other industries, including motor vehicles (23%)	1,440

Aircraft, missiles, and related equipment again leads all other industry in the amount of money that will be spent on R&D. It is impossible to separate the airframe firms from electronics companies in this age of missiles, satellites, flying laboratories, weapons-with-wings, and government "systems" contracts. However, in the table above, purely electronics funds have been separated where possible.

Authorizations are not obligations

A quick glance at the federal budget seems to indicate a paradox. The aero-space industry will spend $3-billion on R&D this year, of which the government furnishes 85%. Yet, government money authorized for this work is $4,026-million, or much more than the total amount to be spent. This is the figure that has been paraded recently, but it represents *authorizations,* not obligated funds. The government actually will contribute $2,550-million.

The federal budget is full of traps for the unwary who try to estimate America's R&D expenditures without reading the fine print. The budget book for fiscal year 1960, which ends June 30, indicates that the Department of Defense will spend $5,760,300,000 for research, development, testing, and evaluation. A Pentagon spokesman told *Industrial Research* that the department actually will spend only $3,894-million.

The difference between authorization and obligation is brought home forcefully in what actually happened in fiscal 1959. The R&D budget (corrected to reflect the new research-development-test-evaluation bookkeeping) called for the Defense Department to spend $5,540,500,000, but only $3,355-million of this actually was obligated.

A trap in the aerospace budget

Another trap: a decrease in funds for military space projects in the fiscal 1960 budget, and an expected further decrease in the 1961 budget, is misleading because it shows less money for space research. Actually, it merely means the services will conduct less space work, and the National Aeronautics and Space Administration will conduct more. NASA funds do not show up in the Defense Department budget. NASA is getting these funds, will spend them, and will get a lot more besides.

(NOTE: One year ago, the Department of Defense ceased reporting an "R&D" budget category, and instituted "RDT&E"—research, development, test, and evaluation. For many months it was impossible to compare fiscal 1959 R&D with 1960 RDT&E. Defense Department fiscal officials worked out an accurate interpretation especially for Industrial Research. *All figures on Defense Department budgets*

A note on forecasting and forecasters

The *Industrial Research Forecast for 1960* is not designed to agree with those issued by the U.S. Department of Commerce, other magazines, or back-room prognosticators. If it were, it would be of little use to you.

Figures contained in this article are a little more valid, and much more meaningful, than many because I•R has gone beyond the usual sources of sometimes superficial information. Forecast director Pursglove and the staff of I•R spent months interviewing research directors, company officials, trade association spokesmen, and government officials in detail.

The first variation from many other R&D forecasts is in the kind of a year used versus the year for which much information is reported. I•R did not use the federal fiscal year, but the more meaningful *calendar* 1960.

The second variation is in categories and in the handling of that largest of all segments of R&D money—the defense research budget. The I•R forecast recognizes a missile industry; most others put a small part of the missile dollar into electrical parts, and the biggest chunk into "ordnance and metal fabricating." This is hardly realistic in a day when the world's largest R&D budget is missiles, and when missile research in turn so greatly influences much other research. As a consequence, I•R has a realistic aerospace category at the "expense" of ordnance and electrical parts categories varying from those in other forecasts.

An important difference between I•R's forecast and others is that the former recognizes and considers the influence of politics, Congressional attitudes, economic disruption, and individual company changes. Several economists told us to ignore the steel strike and tight money because "these things don't affect research." We disagree. Company spokesmen told I•R in detail how their plans have been modified by strikes and credit.

An example of how deep probing has caused dollar estimates to vary from other forecasts can be seen in petroleum R&D. Several major oil companies hold military R&D contracts on missile propellants. These do not necessarily involve oil, but they do influence the total amount of research money to be spent by the oil companies. Such contracts were included, appropriately weighted for their influence on total budgets.

These and other omissions, however, account for only minor dollar variance. In conducting forecast articles now for two years, several strange methods used by some industrial fortune tellers have been uncovered. For instance, here's the recipe of one prominent forecaster:

"Take a National Science Foundation estimate of scientists and engineers to be employed by each industry in 1960 [a survey already several years old]. *Multiply the personnel figures by the average wage that can be expected.* [Let simmer until the memory of oversimplification has dimmed.] *You now have the approximate amount of money that the industry will spend on R&D for 1960!"*

Have you ever wondered why R&D forecasts differ so widely? —THE EDITORS

used here have been converted to RDT&E equivalents. Also, within the past two years, the Defense Department dropped the term R&D in other usage. The individual services still have personnel identified with the "R&D" tag, but on a Defense Department level, it is now "research & engineering.")

Following is a cross-section of research projects to be conducted this year in the aircraft, missile (minus some electronics), and related equipment field:

2. *aircraft and missiles*

The U. S. has scheduled about 25 space shots for 1960, including an experiment designed to carry one of America's seven astronauts into space; space probes to the moon about midyear, to Mars around October, and to the sun and Venus later in the year.

As training of the astronauts *(Project Mercury)* proceeds, McDonnell Aircraft will continue testing the space capsule to house one of them. Designed to withstand any known combination of acceleration, heat, and aerodynamic forces that may occur in reentry, the capsule will be equipped with retro-thrust rockets and parachutes to effect safe descent.

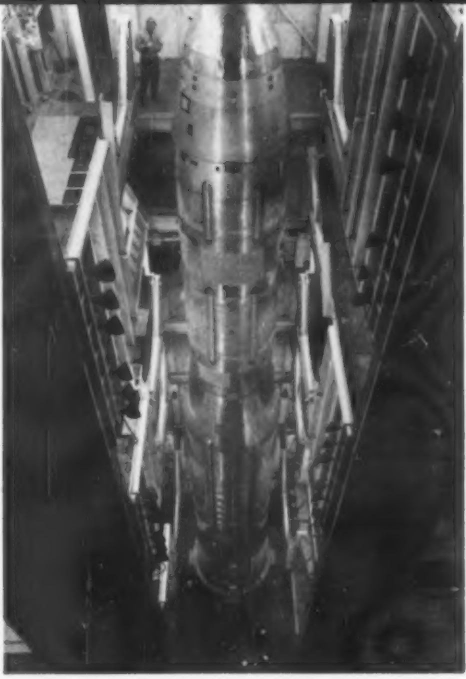
A more exotic aspect of the man-in-space projects is under study by optimistic scientists at Republic Aviation: a moon garden. Basic aim of the project is to determine the lowest pressure at which vegetables, to be grown in lunar greenhouses to supplement more portable staples, will mature. It is part of an Air Force study to determine feasibility of establishing a moon base.

North American's Rocketdyne Division is working on NASA's single chamber 1,500,000-lb.-thrust rocket engine, *F-1*. The same division has a basic contract (Air Force Office of Scientific Research) and an advanced contract (Wright Air Development Center) for ion propulsion system for space project vehicles. Rocketdyne is using a small-scale cesium surface ion motor in its studies. It is a joint effort with Electro-Optical Systems Inc.

Advanced flight testing of *GAM-77 Hound Dog* air-launched ballistic missile will occupy a lot of North American time this year. Even more R&D time will go to the new development contract for an advanced ALBM with longer range.

Catching dummy missiles

Associated with North American and Lockheed in developing launch and support equipment for *Polaris* is Westinghouse Electric. Several million in R&D money slated for Westinghouse is charged to "aircraft and missiles" in the military budget. *Oper-*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AEROSPACE-ELECTRONICS *R&D dominates budgets both in government and private business, as usual. Some projects in progress are:*

1. *Martin-Denver's two-stage ICBM* Titan, *scheduled for the nation's arsenal this year, is to launch the manned* Dyna Soar *in 1961.*

2. Fishhook *missile test retrieval system built by Westinghouse and Lockheed to catch submarine-launched* Polaris *in midair.*

3. *Modular amplifying "matchbox tube" conceived by Westinghouse engineers to fit into printed circuit radar systems.*

4. *Martin-Baltimore's miniaturized digital flip-flop circuit in three evolutionary stages—from left, vacuum tubed, transistorized, superconducted.*

5. *Module and its plastic wafer components developed at Army's Diamond Ordnance Fuze Labs, which uses photographically-printed circuits.*

6. *System Development Corp.'s Q-7 computer, nerve center of the SAGE air defense system.*

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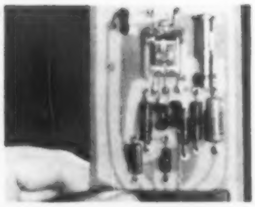
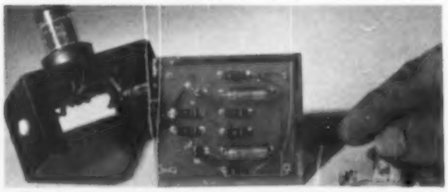
3

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ation Peashooter is running about $10-million per year. This is the Westinghouse catapult launch system for *Polaris* "dummies." The dummy missile is fired into the bay from a mock submarine silo, mounted on land.

Westinghouse will work with Lockheed this year to convert all dummy testing to the Lockheed *Operation fishhook*. The project uses a tower-mounted web to catch dummies launched from underwater, and avoids the lengthy retrieval process of "peashooter."

A Lockheed spokesman says emphasis this year will be on the *Polaris* submarine-launched IRBM, and on space projects (satellites, mostly). The firm is working on plans for a recoverable, reusable booster for vehicles in space projects. Company chemists are studying surface behavior of materials in near space (reactions in low-density atmosphere) and, with Lockheed physicists, will try to develop new plasma-acceleration methods and devices.

The finally settled *Dyna Soar* contract will shape much of Martin's and Boeing's missile future during 1960. Martin will build the booster for the manned, hypersonic space glider. Basis of the power plant will be a Martin *Titan* 300,000-lb.-thrust ICBM, soon to go operational. The Air Force seriously expects *Dyna Soar* to be the forerunner of a rocket-launched passenger plane that, within 10 years, will carry passengers half way around the world in an hour.

Thin-winged Dyna Soar

Boeing, responsible for assembling and testing *Dyna Soar*, has to contend with some unique design problems right away. *Dyna Soar's* wings will be almost razor thin; thus fuel must be stored in the fuselage. However, many factors dictate that some part of the fuel will have to be carried in the wings, at least early in a flight.

The Air Force says the use of aluminum as the main structural material is out because it would place a ceiling on speeds the plane could hit later

in its evolution. This means Boeing will have to plan on thin sandwiches of steel.

Aerojet-General expects to spend more this year on projects ranging from nozzle studies to high-energy fuels and new work in infrared.

Food Machinery & Chemical Corp.'s Grand Central Rocket Co. will expand its R&D facilities and efforts toward developing solid propellants for the Army's *Nike-Zeus* anti-missile missile. More than $2-million will be spent just on "developing and proving a new class of high performance propellants."

The fuels will deliver more specific impulse than any previous solid propellant, and will be ready this year.

Ford's levicar

Ford Motor Co. is in the aircraft field through its *levicar*. Ford's Aeroneutronic Systems subsidiary holds an Air Force contract to evaluate the principle systems involved in levi equipment.

Ford also will continue research this year on a four-passenger levicar it hopes to build next year. It will be used to provide design data for a later 40-passenger rapid-transit levicar. Ford uses the frictionless, rail-mounted vehicle; levipads cling around the rail, separated by a film of compressed air.

Ford expects to spend more than $100-million on research this year, up a little from last. One of the major projects will be the improvement of gas-turbine engines already developed, and the development of new ones.

3. *nuclear energy*

North American Aviation, while essentially an aircraft firm, will conduct some of its more glamorous projects this year in fields outside of aviation.

The sodium reactor experiment and the organic moderated reactor experiment are being conducted by North American's Atomics International Division. The same division is working with Interatom, a West German affiliate of North American-Demag A.G., to develop an organic-moderated ship-propulsion reactor.

Meanwhile, the *N. S. Savannah*, world's first nuclear passenger-cargo vessel, is scheduled to go into operation next summer. One fuel loading will take it 300,000 miles.

A new look at nuclear propulsion for aircraft was offered by Goodyear Aircraft, which announced it has under study a 4½-million cubic foot lighter-than-air craft which would avoid many of the problems of shielding in conventional airplanes.

The challenge of fusion

The real challenge in atomic research for 1960, however, is the har-

The AEC and Navy are talking about major breakthroughs this year

nessing of thermonuclear power. Magnetohydrodynamics, which has become the science of controlling fusion, has come so far in the past few years that Avco Corp. and 10 major private power companies are pooling their resources to put MHD into the factory as a power source.

Avco-Everett Research Laboratory already is generating power on a small scale, using the MHD principle. It simply means substituting a hot, ionized (moving) gas for the wire coil (moving) armature in a generator. However, it is the principle behind fusion and plasma research activities of at least 300 laboratories in the U. S.

One outgrowth of MHD experiments is Republic Aviation's magnetic pinch plasma engine, now in the working model stage. Held to be top contender for the first space propulsion and control engine because of its low fuel consumption and weight, and capable of greater thrusts than the ion engine, it utilizes spurts of electron-ion plasma, heated by nuclear-generated electricity.

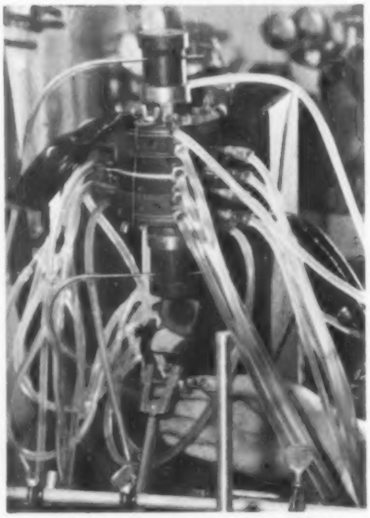
Among other organizations active in MHD research are Lockheed, Ramo-Wooldridge, General Atomics, Westinghouse, General Electric, Tufts University, Chicago Midway Laboratories, and NASA's Lewis Research Center in Cleveland.

Information gained on MHD for immediate use is being applied daily in research on controlled fusion. The Navy and Atomic Energy Commission are optimistic about major breakthroughs this year.

Trapping plasma in a bottle

Los Alamos Scientific Laboratory has announced a new approach toward the possible control of thermonuclear power — "entropy trapping." The more random or disordered a system is, the more likely it is, and the larger its entropy. The idea is to make a plasma change from an ordered (low entropy) to a disordered system. If in doing this the plasma gets inside the magnetic bottle, it becomes difficult for it to climb out again. The magnetic bottle and a hydrodynamic gun now have been perfected and scientists expect to determine by late Spring whether the system works.

The over-publicized *SNAP* series of lightweight nuclear power generators will continue this year, notably by Westinghouse and The Martin Co. (The Atomic Energy Commission—which named the series and pays for the work—still says *SNAP* stands for "Systems for Nuclear Auxiliary Power," in spite of newspaper references to "Satellite Nuclear Auxiliary Power," "Space Nuclear Auxiliary Power," and *Newsweek's* "Secondary Nuclear Auxiliary Power.")



HIGH-TEMPERATURE FURNACE *at NBS can maintain controlled electric arc in an atmosphere of any composition.*

WOBBLE TEST *developed by Goodyear electronically determines fractional irregularities in tires.*

OUTDOOR KETTLE *at General Mills subjects explosive hydrogen to high pressures in conversion of fatty acids to useful products.*

The Martin Co. will carry out the bulk of its $838,000 AEC research contract for the liquid fluidized bed reactor. The LFBR, an attempt to make nuclear power competitive, would use low-enriched uranium in an easy-to-reprocess form and might be able to operate without control rods. The reactor would be turned on simply by forcing the water moderator up through a bed of fuel pellets.

The key problem of pellet abrasion has been solved via the old standby of any lubricating problem — powered graphite added to the reactor water.

Martin will increase its R&D outlay this year as a result of several of its pet projects (other than *Vanguard*) bearing fruit and its outstanding profit record last year.

4. electronics

Well over half of the money available for electronics R&D comes from the federal treasury. Major fields expected to burst into full bloom this year are modular concepts for throw-away equipment and molecular electronics (molectronics).

Westinghouse Electric has a "matchbox tube" undergoing test in radar intermediate amplifier stages. It is designed to fit into printed circuits, and lends itself to automatic feeding of all components for assembly in module use.

The modular work appeals especially to the new strategic army concept, which calls for missile launchers, fire-control centers, electronic intelligence gear, data reduction centers, and other equipment best repaired on the battlefield by throwing away faulty components and replacing them with packaged circuits.

The demand for order-of-magnitude reductions in component size makes the new development of molecular electronics attractive. The principle here is to eliminate individual components and replace them with one component that combines all the functions of a circuit.

Example: Westinghouse has built an optical telemetry circuit out of one small circuit that replaces 18 conventional components and 16 soldered

in controlling thermonuclear power.

joints. The moletronic "circuit" has two soldered joints — input and output — and reduces the size of the equipment from about 1½ *cubic feet* to less than half of a *cubic inch!*

Photoelectric power

In other electrical projects, Westinghouse is working on one of the roadblocks to practical generation of photoelectric power — high internal impedance. The company's Astronautics Institute has developed cells with impedances of about 3,000 ohms. A previous photoelectric cell had an internal impedance of about one megohm.

GE and Republic Aviation have proposed a method of lighting whole cities with small, efficient generators operable by shooting electronics and ions through a magnetic field. Intensive R&D may begin in 1960 on the plasma generators, which could pay off in five to 10 years. As much as 1-million watts could be generated by shooting a stream of plasma at speeds three times sound through a magnetic field only three feet long and with the magnetic poles six inches apart.

New electronic computing techniques limited only by the speed of light will be investigated by Remington Rand, Philco, Minneapolis-Honeywell, IBM, and RCA this year. Experimental techniques already have performed simple computations at speeds of 500-million times a second. If perfected, the new computers could operate 1,000 times faster than present systems.

Fuel cell breakthroughs

A hybrid electrical-chemical development to receive intense interest during 1960 is the fuel cell. That dozens of companies are pushing hard for new fuel cell breakthroughs comes as no surprise to viewers of magazine and TV advertising, where the cells already seem to have replaced the internal combustion engine.

After a decade of research, very high-efficiency (60%) fuel cells are being predicted in earnest as replacements for tractor or auto engines, and power sources for everything from spaceships to radio transmitters. With such a prospect, no company even remotely concerned with power generation can afford to ignore the fuel cell.

This year, fuel cells will approach 300 watt-hours per pound (as against 10 watt-hours per pound for a standard auto battery). Research will continue in finding the right combination among electrolytes, electrodes, and fuels (both exidant and reductant). GE, National Carbon Co., Allis-Chalmers, and the Army Signal Corps are representative of groups studying "hydrogen-oxygen" fuel cells, in which these elements are the fuels and a concentrated alkaline solution serves as the electrolyte.

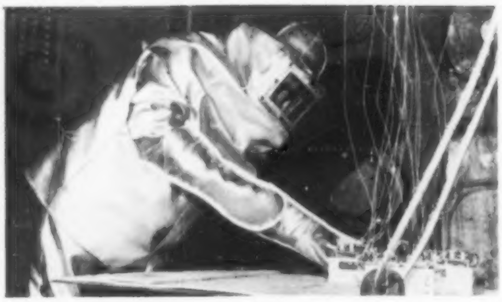
Most fuel-cell firms also are investigating the "ion exchange membrane fuel cell," similar to the hydrogen-oxygen cell except that it has a porous membrane in which are fixed groups of ionized atoms. This type of cell is being pushed because of its low operating temperature, absence of any liquid electrolyte, and good power-to-weight and power-to-volume characteristics.

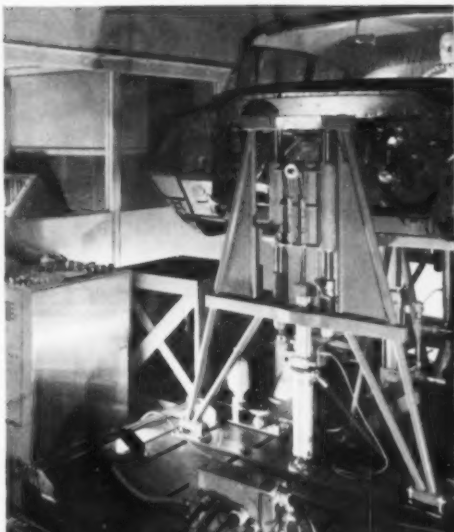
Other kinds of fuel cells are the GE and Lockheed "Redox cell," which uses chemical intermediates to convert the energy of its fuels into electricity; the "regenerative fuel cell," a closed system being investigated by Mine Safety Appliance Research Corp., in which reactants must be regenerated continuously at high temperatures from the products of the reaction; "molten salt electrolyte," a type under consideration mostly in Europe and characterized by high operating temperatures, fused salt electrolytes, and cheap fuels such as carbon monoxide or natural gas; and "consumable electrodes," based on the continuous consumption of materials functioning both as fuel and electrode, researched by National Carbon, Aerojet-General, RCA, and Dow Chemical.

5. *chemicals and oil*

In fields more normally considered chemical, intensive research will continue during 1960 in protein chemistry, especially photosynthesis and enzyme chemistry. The gray area between organic and inorganic chemistry will be explored thoroughly. This includes inorganic polymers, silicones, and fluorocarbons. Physical chemists will continue research on fusion, free radicals, solid state, and intermetallics. Solar energy will occupy chemists in two fields — photosensitive materials and sea water to fresh water conversion.

One of the most exotic areas of chemical research this year is in a joint program of the Army Surgeon General's R&D Command, the Atomic Energy Commission, Air Force, Navy, and Public Health Service. Chemists in the program are seeking antiradia-





POLYPROPYLENE STRANDS *(left) are tested at Esso Research Center to find maximum tensile strength and resistance to abrasion. The plastic is made from propylene, a refinery gas. Above, Sundstrand Aviation technician wearing a proximity suit tests components in a chamber that provides temperatures from —100 F to 1200 F. Ride simulator at right is analog computer controlled at General Motors Research Labs.*

tion drugs. These are to counteract the effects of ionizing radiation on the battlefield or in industry.

Most promising chemicals are sulfhydryls; more than 100 have undergone preliminary screening and nearly 50 merited further study. So far, however, the most effective compounds are dangerously toxic when taken in amounts large enough to counteract radiation.

Gas chromatography comes of age with the development of highly sensitive detectors for volatiles capable of measuring parts per billion. Applied to the objective measurement of odor at Evans Research & Development Corp., new chromatographic developments are finding applications in trace analysis, flavor research, medical problems, and air pollution.

Research without subsidy

The chemical industry this year still retains the honor of being one of the few major industries that supports almost all of its own research without government subsidy. (This may not necessarily be a prestige point; on more than one occasion, missile leaders have called publicly and before a Congressional committee for the chemical industry to take more government missile R&D contracts.)

As last year opened, the chemical industry had completed laboratories costing more than $70-million. This year, the industry will spend just over $700-million on research — only 9% of it paid for by the government. It has one of the highest research-to-sales ratios of all major industries: 3 to 4% of every dollar goes back to the lab.

Where is the chemical industry headed? Here is what J. Peter Grace, president of W. R. Grace & Co., says:

- Oil companies will become a more integral part of the chemical industry as more and more new petroleum products are developed.
- More chemical companies will enter the petroleum field to control the source of their petrochemical activities.
- Non-chemical firms in the food, steel, machinery, and other fields will move into chemicals in greater numbers to utilize their byproducts more efficiently.
- Chemical industry research budgets will reach $1-billion by 1970.

Petroleum chemists will emphasize stereo-chemical research this year, the source of a more rugged and versatile breed of plastics, rubber, and chemicals. Esso, du Pont, Hercules Powder, Montecantini, Firestone, and Phillips Petroleum are analyzing and testing hundreds of different catalyst combinations. Applications are in stronger and lighter components for missiles, automobile bodies, and construction of buildings.

One of many new synthetic materials derived from oil is a butoxy resin developed by Esso Research & Engineering Co. A thin coating of the resin has better properties for protecting pipelines from corrosion than much thicker coatings of conventional materials.

6. metals

The aluminum industry is going all out this year to develop new large-volume markets through research — and advertising. Alcoa spent $18-million on research in 1959, and plans this year to begin construction of a gigantic research center near Pittsburgh to cost more than $30-million and sprawl over 2,400 acres. The center will be the largest of the world's metal industries.

Reynolds Metals reports that new defense equipment will include these aluminum ordnance items: aluminum armor-plated personnel carriers and self-propelled guns, trucks, airborne tractors, cranes and booms, airborne shops, pipelines, assault ferries, bridges, amphibious vehicles, boats, flying reconnaissance cars, railway cars, off-the-road trains, aerial tramways, and radio telescopes.

'Clean' aluminum

Besides low cost and low density, there's another reason the services are becoming more interested in aluminum. It retains radiological contamination for a shorter period than other structural materials, and can be decontaminated easily and quickly.

Rare metals will be investigated vigorously in 1960. One example is Union Carbide's study of the properties of scandium. The rare metal is as dense as aluminum but melts at temperatures some two and a half times higher.

Testing of metal parts should improve as a result of research. General Mills, through its newly acquired Magnaflux subsidiary, will develop eddy current test systems for measuring conductivity and permeability of metals. Principal advantages of eddy current systems are the high inspection speeds possible, relatively low costs, and an adaptability for automatic control use.

Eddy current inspection is a process whereby a coil carrying alternating current induces currents in the material or part being inspected. The resulting changes in the electrical parameters of one or more coils can be

analyzed for sorting, finding defects such as cracks or inclusions, or for gaging. The technique can measure both magnetic and non-magnetic materials.

Another Magnaflux project for 1960 is a new testing system for accurately locating and recording lack of braze, excessive braze, deformed core, and other irregularities in brazed honeycomb sandwiches. Several aircraft firms now are evaluating the system.

Research budgets in the steel industry will be up about 2 to 2½% during 1960, but how much the strike will affect research expenditures remains to be seen. (R&D in nonferrous metals will go up about 12%.)

A super supersteel

U. S. Steel's principle research interest is in developing lighter, higher-strength steels, mostly for missiles. The company expects a major breakthrough — a steel that will exceed the most recent new steels in all desired characteristics. A USS official says the new metal will be superior even to the company's recently announced "strux," identified as a "superalloy with 7% more strength-per-weight-unit than other constructional alloy steels."

The blast furnace certainly will not be eliminated in 1960, but steel companies will work hard on direct ore reduction, and more oxygen will be used in steelmaking than ever before in the U. S.

The machinery and capital goods industry had hoped to spend more this year on R&D after dropping the research budget by 2.5% last year. But expenditures will not be decided upon until the steel strike's full effects are known.

One of the largest trade associations in the field reports that it has not surveyed its members on proposed R&D budgets since 1954. The reason: research and development are meaningless terms that cannot be surveyed; they mean different things to different companies. This is the same problem the Department of Labor has had in trying to estimate the needs for new engineers and technicians in "research" and "development" laboratories.

An official of one of the leading companies in the field confidentially told *Industrial Research* that "A lot of companies are cutting their R&D budgets — others are dropping the term entirely. One reason is that Congress wants to see military hardware, not research on hardware.

"The other reasons is it's time now to roll the production lines and cash in on R&D money that already has been spent. A lot of experimental programs will be dropped. The companies that drop them will substitute low-cost "new programs" that are really just studies to explore the possibilities of actual research programs."

Lubricating with gas

One company, however, did tell I•R about one of its major efforts for 1960. American Machine & Foundry said it will further its recent work on gas-lubricated bearings. AMF has high hopes for bearings as components in military applications.

Speeds ranging from 165,000 rpm to 500,000 rpm in turbo-compressor units and shaft-rotor systems are possible with the bearings. Conventional oil-lubricated bearings permit maximum speeds of only 100,000 rpm. Besides permitting increased speeds and eliminating vibration, gas-lubricated bearings permit operation over temperature extremes that would either freeze or vaporize other lubricants.

The mechanics of food

Research in the food processing and packing industry has been climbing steadily in recent years. A National Canners Assn. economist expects the R&D budget to rise again this year, for all foods, not just canning and preserving. As in most industries, the food R&D budget is geared to profits, and the canning industry expects its profits to be up this year. One reason is the impetus given canned foods sales by the new public taste for mixed juices.

Food people say we will have more foods with built-in services, such as cooked foods and meals. Container sizes will increase, due to the increased average family size and more suburban living.

On the other hand, irradiated foods are still a long way from the neighborhood grocery store.

8. medicine

Medical research will increase during 1960, and part of it will be done by industrial laboratories. How much industry's share will be is nebulous. However, several large chemical and petroleum companies have medical centers that conduct medical research in addition to devising safety programs.

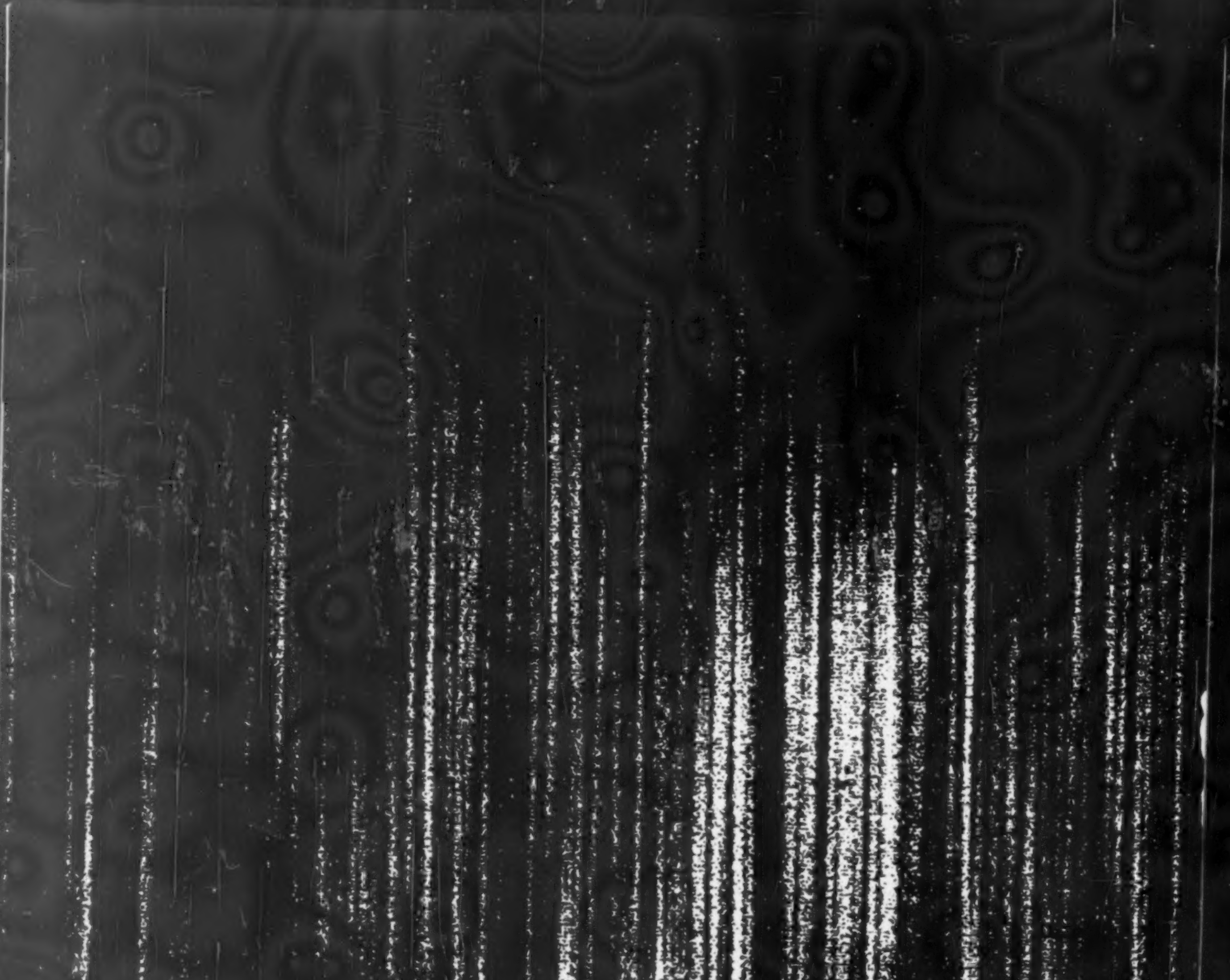
Some of the federal money for this work will come from the National Institutes of Health. NIH expenditures have quadrupled in six years to the consternation of President Eisenhower and NIH officials.

The President pointed out that there is a limit to the rate at which research can grow, yet grow soundly. He fears the large increase in money may lower the quality of approved projects, divert to research the manpower needed in teaching and medical practice, and discourage the expansion of non-federal support of medical research.

A new technique for the prolonged storage of whole blood that may revolutionize the present blood bank is expected to become a practical reality in 1960 by scientists at Linde Co., a division of Union Carbide Corp. Investigations have shown that quick freezing to —320 F with liquid nitrogen offers indefinite storage possibilities with maximum recovery of red blood cells.

The project is representative of the tremendous variety of medical research to be conducted by industry — research which at once includes drugs, medicines, electronic machines and optomechanical, electromechanical, etc. tools for the physician or surgeon.

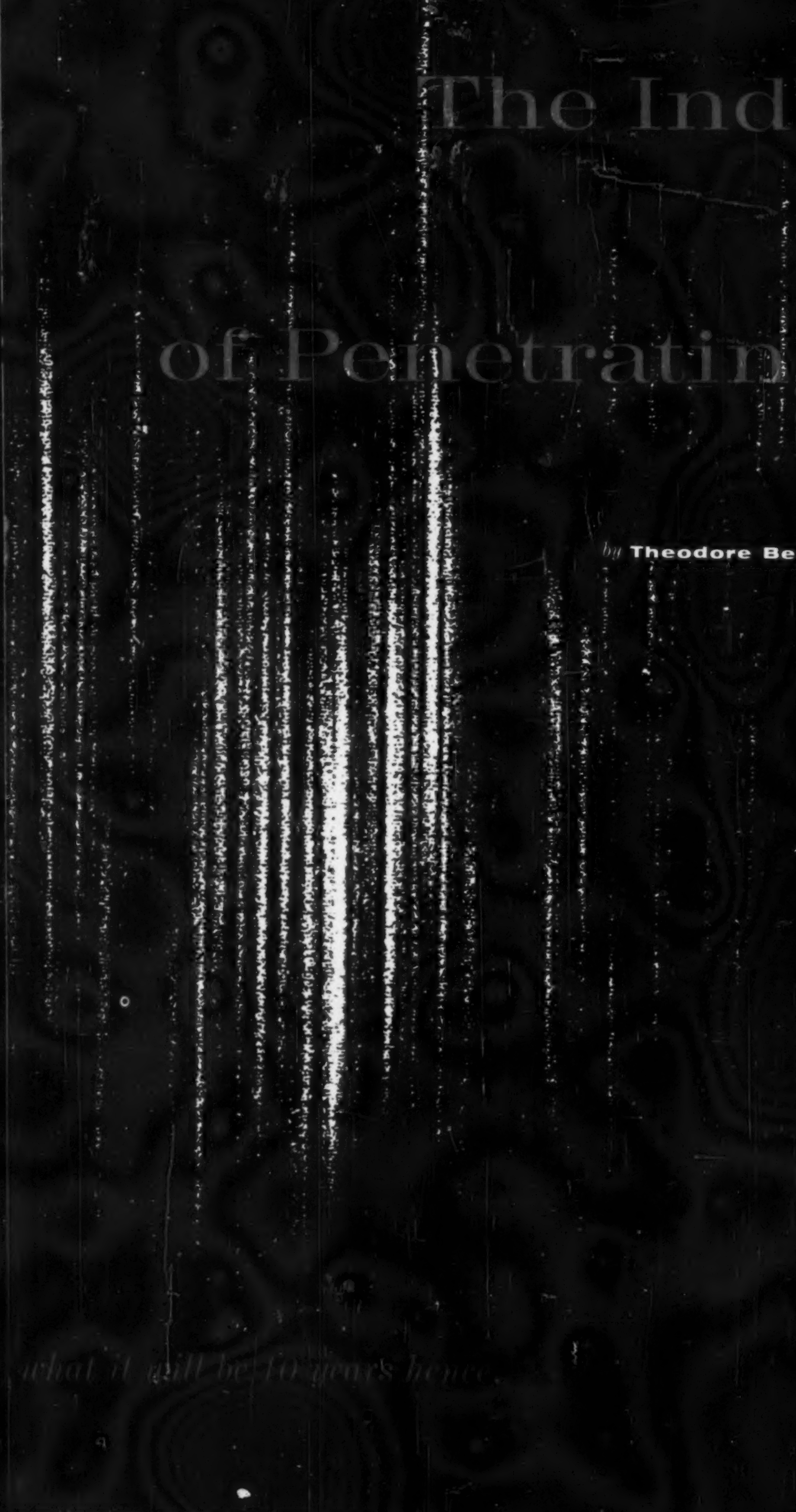
Whether all or any of the projects reviewed here will bear fruit during 1960 is uncertain, of course. From a company standpoint research is a gamble, but even more so is the lack of research. ■



Total x-ray sales in the U.S. last year totalled $30-million—half of

General Dynamics radiograph

The Industrial Uses of Penetrating Rays



what it will be 10 years hence

by **Theodore Berland,** *an I•R contributing editor*

In the 64 years since its discovery, the x-ray (and later the gamma ray) has made bold contributions to science and technology. More than that, Wilhelm Konrad Roentgen's rays are furnishing an important link in the circle of feed-feedback-and-control that is America's gathering industrial revolution in automation.

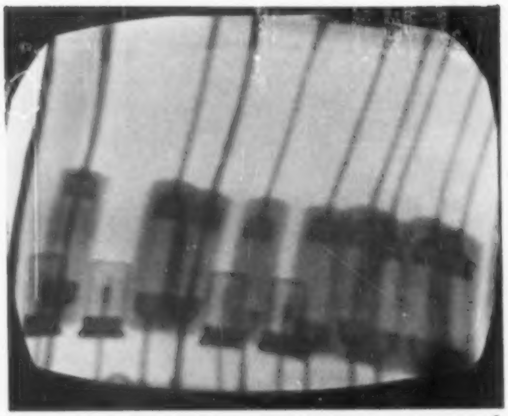
In 1890, "classic" physics — except for a few more experiments and decimal places — had pretty well explained all physical phenomena.

As one physicist described more than 50 years later, "Newton's laws of motion and gravitation, the concept of conservation of energy, the inverse square laws of magnetism and electrostatics, the kinetic theory of gases, Maxwell's equations, and Faraday's laws fully accounted for everything from the motion of the planets and the operation of an engine to the Brownian movement."

The photoelectric effect, discovered in 1887, was curious, but would remain so only temporarily, everyone was sure.

A crack in classical physics

Then, in 1895, the bearded Bavarian professor announced to the December meeting of the Wurzburg Physico-Medical Society his discovery that a Crookes tube — which he had been using to study the nature of the



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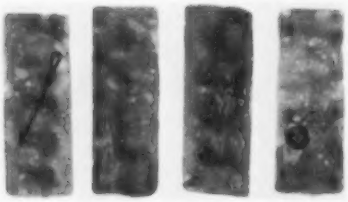

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stream of electrons between electrodes in a near-vacuum — produced unseen rays. This invisible light, to which he affixed the mathematical symbol for the unknown, x, could pierce such objects as a 1,000-page book to illuminate a screen of barium platinocyanide or form an image of hand bones on a photographic emulsion.

The crack in classic physics had been made. Other wedges that hammered it open still further were the discoveries of radioactivity by Becquerel in 1896, of polonium and radium by the Curies in 1898, and of the gamma ray (which, like the x-ray, is an electromagnetic radiation generally of wavelengths that range from several to several hundredths of an angstrom) in 1900 by Paul Villard. On top of the classical ruins physicists began constructing the new science.

Scientists discovered new and exciting phenomena in x-rays: 1896, x-rays were found to cause the ionization of air molecules; 1906, x-rays scattered from an atom of carbon revealed it has six electrons; 1910, heavy elements emitted characteristic radiation when bombarded by x-rays (fluorescence); 1912, x-rays were diffracted by crystals; 1913, x-rays were reflected; 1914, the wavelength of an x-ray beam was related directly to the atomic number of the material in the target; which helped establish in 1919 the present concept of the atom; 1923, an x-ray scattered by an atom changed its wavelength as a result of giving up some of its energy to an electron.

Except for the small-scale manufacture of Crookes tubes and of auxiliary electrostatic equipment for laboratory and medical use, industry pretty much ignored the x-ray. Then, in 1913, through the person of Dr. William D. Coolidge of General Electric, it produced a dependable, stable, and controllable high-vacuum tube that would make x-raying practical.

The Coolidge tube used a white-hot filament to "boil off" electrons. Racing under electrical attraction, these electrons slammed into brother electrons in the atoms of a tungsten target, forcing them to yield x-rays.

In various sizes, shapes, and power requirements, and with suitable refinements, the hot cathode tube design was adopted for hundreds of medical and dental, diagnostic and therapeutic devices.

100% nondestructive testing

Industrial x-ray's late start came in 1922 at the War Department's Watertown Arsenal, Mass., with the installation of a 280,000-volt (or 280-kv, for kilovolt) apparatus. The fan-

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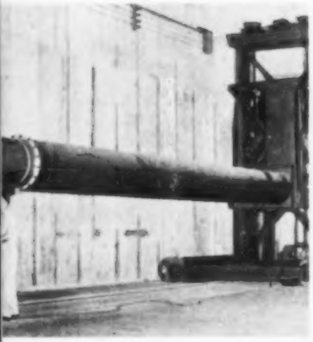


RAY-LESS INDUSTRY *is hard to imagine today, so prevalent are applications of X and gamma rays:*

1. *Gusts of a potted component not only are revealed, but televised for remote inspection in this TVX system by GE.*

2. *Even candy bars can get in trouble without x-ray inspection.*

3. *A High Voltage Engineering Co. generator is mounted on a long boom for panoramic interior radiography. The unit can define flaws through 10 inches of steel.*

4. *X-ray microscopy reveals mosquito insides.*

5. *Suspected weak area in a seam weld is backed with film, and*

6. *X-rayed with a remotely controlled unit.*

7. *The same unit, a Picker X-Ray Corp. model, also can radiograph a 360-degree weld in a single exposure.*

8. *It all started with Wilhelm Roentgen (an actor is shown here), who explained, "I did not think; I investigated."*

shaped beam was directed through large castings and onto sheets of photographic film that after development were inspected to detect minute cracks and blowholes in the metal. Thus radiography, a new means of 100% nondestructive testing, had been introduced.

Five years later, all aircraft parts were inspected radiographically by the aluminum industry. Next to grab on to x-rays were pressure-vessel fabricators, who in wanting to replace rivets as fasteners, used radiographs to assess new techniques of welding.

Industrial use of x-ray received its biggest push in World War II under the pressure of government specs and the growing war. The invisible light that could reach into things and reveal hidden flaws helped speed the production of all kinds of heavy war equipment: jeeps, tanks, trucks, bombers, and battleships.

Virtually a splinter specialty in 1939, industrial x-ray manufacturing found itself full-grown in 1945. Sales began to multiply.

$30-million for x-rays

In 1959, according to E. W. Philleo, industrial marketing manager at GE's Milwaukee X-Ray Department industrial x-ray sales in the U.S. totalled $30-million. *In the next 10 years this figure probably will double.* Forecasts beyond this would depend on new developments in the uses of radiation, something hard to foretell, he points out.

Because radiography is the largest single field in which x-rays are used by industry, there has been much effort toward extending the power of x-ray tubes in two directions.

The higher the voltage of the tube, the greater thickness its rays can penetrate. For "seeing" through feet of steel, accelerators have been built that generate x-rays in million electron volt (mev) ranges. At the same time, you don't need a drop forge to break a watch crystal. So tubes have been scaled down to portable sizes and weights that can pierce only fractions of an inch of metal.

Among today's light-heavyweights are GE's 1- and 2-mev x-ray tubes that use the cascade principle of spaced voltage kicks developed by Coolidge. Coupled with a resonant transformer — which eliminates the need of an iron core — this "Resotron" is a self-contained mev unit.

Other light-heavies are High Voltage Engineering Corp.'s Van de Graaff generators, which build up their charges electrostatically and reach 4-mev. The Tandem Van de Graaff modification can reach 10-mev. Another electrostatic machine is Radiation Dynamics Inc.'s 1.5-mev "Dynamitron."

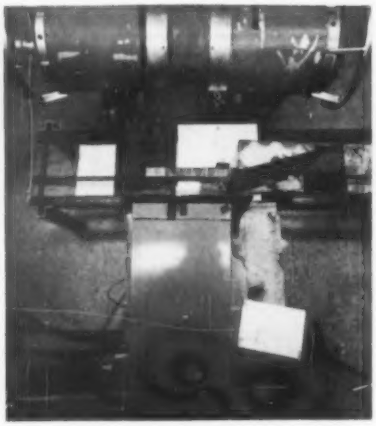
Besides reaching high energies, these mev machines can produce x-rays that spray 360° circles around their targets. This means not only that the rays penetrate up to eight inches of steel, but that test items can be ringed around the source.

Artillery shells, for instance, can be propped up on revolving tracks and exposed at the rate of five per minute. Or the source can be placed inside large-diameter castings to expose the entire circumference at once.

The most powerful industrial source of x-rays is the betatron. GE's 15-mev and Allis-Chalmer's 24-mev betatrons are essentially smaller models of the huge 350-mev atom smasher developed at the University of Illinois by Dr. Donald W. Kerst (now at General Atomics). In the betatron, electrons contained in a hollow ceramic "doughnut" are accelerated by magnetic fields to speeds near that of light.

Betatrons can be cheap

Betatrons are big and expensive but can be money-saving in very heavy-duty work. A three and a half-



BIRD'S EYE VIEW *of an x-ray operation shows a honeycomb construction sample on a conveyor belt (at center of adjacent photo), x-rayed by a GE power unit, at top. The operation is enclosed in a concrete room for protection, and a television camera, bottom, transmits the x-ray image to a receiver in a separate room for inspection (photo, far left).*

Penetration depends on a ray's energy, not its source; for instance, both co-60 gamma rays and x-rays will pierce a foot of steel.

ton 15-mev betatron, for instance, can radiograph 12-inch thick steel in 11 minutes, where it takes a two-mev cascade unit more than two hours! The six-ton, 24-mev betatron is about as fast up to this thickness, but faster from then on.

While the big machines are spectacular, the workhorses of radiography are the conventional x-ray tubes of 140 kv to 300 kv. These inspect castings for discontinuities, shrinkage, cold cracks, impurities, gas bubbles, surface irregularities, and dendritics, ascertain the soundness of welds, and are used for a myriad of production jobs that include inspecting tires for cord alignment and carcass breaks, locating foreign objects such as bobby pins in candy bars and wheevils in wheat, and detecting ceramic resistors ruined by running solder.

Among the smallest radiographic units are Picker X-Ray Corp.'s 40-90 kv, 37½-lb. "Hotshot" and GE's 70-140 kv, 46½-lb. LX140, used for such field inspection jobs as pipe lines and aircraft.

The smallest industrial x-ray source is the 20 kv tube used in x-ray microscopes. Employing magnetic "lenses" to focus electrons onto a target, they produce x-rays from points less than one micron in diameter. This gives magnifications up to 1,500 for uses that include studies of metal grains, pinpointing the contaminants that cause the breakdown of rubber insulation, and micrographs that show the deterioration of textile fibers under various chemical and physical treatments.

The nuclear reactor brought a new source of penetrating rays into being: radioactive isotopes, which give off gamma rays (so-called to distinguish the radiation from rays given off by machines). Principal among them is cobalt-60 because of its five and two-tenth-year half-life and 1.2-mev energy. Next come cesium-137 (35 years and 670 kv), iridium-192 (75 days and 400 kv), thulium-170 (27 days and 60 kv), and radium (1580 years and 1600 kv).

X-rays resurrected

When the government first made radioisotopes available in 1946 many enthusiasts forecast the death of the x-ray machine. But x-ray tubes and isotopes both have their advantages and disadvantages.

Regardless of how the radiation is generated — nuclear disintegration or electrically — the penetrating power depends on the ray's energy. Cobalt-60 gamma rays and Resotron x-rays both will pierce 10 inches of steel, for example.

The Budd Co.'s Nuclear Systems points out that isotopes are highly portable, require no power source, can be slipped inside small diameters, and have no mechanical parts to wear out.

Picker alone seems to have straddled both sides, offering both tubes and isotopes.

GE, the nation's largest producer of x-ray machinery, has stayed completely x-ray minded. It points out that while the radiation energies are similar, the beams from x-ray tubes are more intense, allowing shorter exposure times (six inches of steel can be photographed in one minute by a Resotron, 15 minutes by a Picker "Cyclops" Co-60 unit). X-rays are constant, while gamma rays decrease to half-life. X-ray beam sources can be confined to a fraction of a millimeter while a radioisotope can be as small as an eighth inch. (The smaller the beam source, the better the resolution of the radiograph.)

Further, says GE, tubes are safer: in case of a shattering accident, the tube may be destroyed but the radiation is "off;" with an isotope accident, "hot stuff" can be splattered over part of the plant. Also, isotope users must hold a license from the U.S. Atomic Energy Commission.

While many more versatile ray sources have become available, the graph part of radiography dragged behind. Then came photographic films with better sensitivity, density, contrast, and resolution.

The dry-photo electrostatic technique developed by Haloid-Xerox Corp., which eliminates the darkroom, accentuates fine detail in certain applications and provides for duplication.

Fluoroscopy, where the radiograph is viewed directly on a screen, has been used on a limited basis, mainly to inspect grains, fruit, and vegetables for spoilage. Materials denser than a quarter-inch of steel couldn't be fluoroscoped because high-energy rays would be a danger to the operator as well as reducing the contrast on the screen.

Brighter fluoroscopy

Then, three years ago, North American Philips Co. introduced its "Norelco" industrial image intensifier. The device raised by 1,200 times the brightness of the image on the glowing

screen. Shortly after, Westinghouse marketed its "Fluorex" image intensifier. Old quarter-inch steel energies could be used for inches of steel.

Late in 1958, GE introduced a new invention called "TVX" which promised to advance industrial fluoroscopy by giant steps. Developed by Dr. John E. Jacobs, it provides x-ray images on a 12-inch television screen that are 10,000 times brighter than those of conventional fluoroscopes, can be viewed in normal room lighting, and at one or several points up to a quarter of a mile from the assembly line.

TVX gets its high intensification by directly converting x-ray energy into electronic energy with a lead monoxide screen. Norelco's and Westinghouse's intensifiers, on the other hand, electrically amplify the fluoroscopic light image.

GE's James Heck, industrial radiographic specialist, believes that in a decade systems like this could replace about 75% of all radiography now being done on film. "Industry is becoming automated. We're not going to build a part in a minute and then wait 30 minutes to see if the part is any good," he says.

TVX—geared to the '60s

Evidence that TVX is geared to the 1960's are some of its present uses: inspection of honeycomb steel airplane skin panels, and detection of performance-affecting b u b b l e s and cracks in solid missile fuel. More mundane uses include on-line inspection of propellers, potted electronic components, canned nuclear fuel elements, and heating elements and thermostats of electric frying pans.

Ten years from now, TVX well may be replaced by a new picture brightener that amplifies images 50,000 times. It is being developed by London's Imperial College of Science.

Radiography, x-ray's big arm, falls under the general heading of "absorption" among the categories of uses of the invisible light: heavy material absorbs more than light material. This means that you beam the rays through one side of a sample and measure the differences in density on the other side.

Replace the image former with a semiconductor such as cadmium sulfide and you have a whole new field of radiation applications. This particular crystal is sensitive to x- and gamma rays, and converts them directly into electrical energy.

In its simplest use, cadmium sulfide checks the height of ingredients in sealed opaque containers on conveyor lines. More of the rays are absorbed by the can and its contents than by

the can alone. So the low-power beam is adjusted to the height above which cans should be filled. Overfill-underfill signals from the crystal are distinguished by electronic circuits; these activate either reject counters or reject machinery. Also, several crystals may be stacked to measure the exact height of can contents and a signal fed back to regulate the filling machinery.

GE's entry in the field, "Hytafill," now is used to standardize the contents of packaged B. T. Babbitt detergent, Miller beer, and Cott ginger ale. Industrial Nucleonic Corp.'s "Accu-Ray" system gages can content with the help of a radioisotope.

A difference in fruit

Another variation, originated by the University of California, differentiates frost-damaged from sound fruit by the differences in their characteristic absorptions. The system is being developed to evaluate 10 units of fruit a second.

The same principle that keeps constant levels in the canning industry keeps constant the thickness of steel used in those cans. This is density gaging. Here the beam, instead of triggering yes-no circuits, is used to measure within a mil accuracy the thickness of strip steel emerging from the rolling mill.

According to a recent Commerce Clearing House-AEC study, density gaging is the largest single use of radioisotopes in industry. The savings in cigaret manufacturing, where it determines the firmness of tobacco packing, is estimated to be about $50-million alone. Isotopes aren't the only source used; they work hand-in-hand with x-ray tubes.

In operation, radiation density gages beam a split ray to measuring and reference detectors. Between source and reference detector is a wedge of the material, say cold rolled steel for example, set at the exact thickness desired, say 600 mils. When the amount of radiation absorbed by the rolling steel varies from the amount absorbed by the reference wedge, a deviation signal is generated. In an automated steel mill, this signal would be fed to a control to ease or increase the pressure on the rollers and the tension on the sheet.

Radiation sensitive crystals, as well as Geiger counters and scintillators, also are used in a radiation field held by isotopes alone: tracing. Radioisotopes, because they place the radiation source right in the materials, are used to measure wear of such items as piston rings, trace chemicals through processing plants, and measure the flow of materials across national pipelines.

Emission on the line

Even more fascinating links between radiation and automation lie in the two other general fields of x-ray application: emission and diffraction. Both have been used in analytic work by metallurgists, chemists, and mineralogists for years, using such equipment as that produced by RCA. Now these esoteric techniques are stepping out of the laboratory and onto the production line.

The principle of the first, emission (or fluoresence, as some physicists prefer to call it), is that each chemical element emits x-radiation of characteristic wavelength when its atoms are bombarded by high energy x-rays.

It is used in Applied Research Lab's "Quantrol" and GE's "XEG." Full-spectrum beams from standard x-ray tubes are turned on the stream of rejected material from a copper flotation plant, for instance. In the detection unit are crystals naturally tuned to the characteristic x-ray frequency of copper.

The intensity of this ray is a measure of the concentration of copper present. Converted to an electrical signal, it can be fed into an analog computer linked to automatic controls that regulate temperature, pressure, etc., to minimize the copper in the float.

"Continuous chemical control of a process is now commercially available," says Paul S. Goodwin, of Applied Research. The analysis is truly continuous and simultaneous since no samples are taken from conveyors or pipes. Also, it makes no difference whether the material is gas, liquid, or solid, a mixture of all three, or whether it's hot or cold. And the device is sensitive enough to detect traces of a millionth of a gram of all of the elements heavier than magnesium.

Besides ore refining, the devices now are used routinely to detect metals in oil products, the exact ratio of metals in alloys, and the thickness of platings on steel.

A pattern of rays

The second analytic principle, diffraction, has been used to identify compounds and their atomic arrangement in various crystalline states. The principle is this simple: each crystal scatters x-rays in a pattern and of a frequency peculiar to the specific arrangement of its atoms.

Rolf Edholm, product planning manager of GE's industrial x-ray section, feels that diffraction ultimately will move out of the laboratory and onto the production line, primarily for accurate control of complex chemical products such as pharmaceuticals.

X-rays and x-ray machines also have opened the door to new applications of another kind of penetrating radiation, that of electrons.

Until they found ways to cool their tubes, early x-ray workers were annoyed by their targets melting from the intense heat of bombardment by electrons. Now Temescal Metallurgical Corp. of Richmond, Calif. is extending this annoyance to purify such refractory metals as columbium and tungsten. Once perfected, their technique may replace vacuum arc furnaces used by such refiners as Wah Chang Corp.

Take the target off a mev x-ray machine and you have an energetic stream of electrons that are being used to sterilize surgical instruments, preserve food, vulcanize tires, treat silicone rubber so that it can be sold as an insulating tape, and raise the temperature properties of polyethylene.

Petroleum manufacturers are working towards new gasoline cracking processes based on irradiation repolymerization and pharmaceutical concerns are looking toward routine electron sterilization of drug products.

The danger of x

The chemical effects of radiation brings up another and important point concerning the x-ray: its biological effects. There are no two ways about it — radiation, *per se*, is dangerous to man.

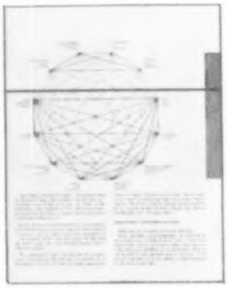
But how dangerous is it in the plant?

"The hazards are always there," concedes Dr. E. Dale Trout, GE radiation physicist and member of the National Committee on Radiation Protection. "But the degree of hazard is reduced in inverse ratio to the knowledge of the people who use it."

Since the beginning of industrial radiography, he points out, x-ray equipment has borne warning labels and safety officers have been consulted so that installations could be planned with personnel protection in mind.

The "bible" for such installations is the U.S. Department of Commerce's *Handbook 60*, which every purchaser receives. It shows how to enclose high-energy sources in lead or concrete walls, how thick these must be, how scatter and leakage are controlled by barrier doors, and points out remote controls that may have to be provided.

Of course, no plant equipment can be installed without safety precautions. And once these are accounted for, x- and gamma rays yield a rewarding look into the unknown that save countless breakdowns, failures, spoilages, manhours and dollars, and provide unique new nondestructive quality controls in this age of automation. ■



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A few of the pages from Stimulus

Stimulus (copyright 1960) has just gone on sale in bookstores for $6.75. Readers of this magazine, however, may order the book direct from the publisher for $4.95. Or they may get a copy free with a three-year subscription to Industrial Research, for $13.

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PROFITABLE PROJECTS

I·R

The following information by the I·R Washington staff is offered as a guide to the investor, the new-product market analyst, and the technical executive or engineer concerned with dollar returns from research.

Electronics

Don't be too hasty in adapting new electronic devices to expanding markets — or in buying stock of companies that do. The Electronic Industries Assn. cites the unfortunate experience of many companies with vacuum tubes between the two world wars, and emphasizes that mass production of components before they are proven fully could be disastrous.

American transistor manufacturers claim that Japanese transistors sell for less than 80 cents as against $1.35 for a comparable domestic product. In 1957 only about 100,000 transistor radios were imported as compared to close to 2-million estimated for 1959. The Department of Defense fears this will undermine domestic industry — eventually reducing R&D efforts to the detriment of national security.

But the high-purity, single crystals of silicon carbide being grown in furnaces at Stanford Research Institute may revolutionize the transistor industry. Transistors and diodes employing germanium or silicon for semiconducting elements are limited to maximum operating temperatures of 190-450 F, whereas those made of silicon carbide can operate at temperatures up to 1800 F. Industrial applications and missile technology are some of the promising areas.

Stamp-size transistor circuits developed by Diamond Ordnance Fuze Laboratories are the latest in miniaturization. In 1/200 of a cubic inch, the new circuit can replace a one-cubic inch transistor circuit. The Army estimates annual savings of $200-million by utilizing the development.

International Business Machines Corp. has a machine capable of recycling helium from liquid to gas and back. Since it can keep temperatures as low as —452 F, it is expected to be used for experiments on IBM's new "cryogenic" computer circuits.

Instead of using tubes, transistors, and magnetic cores in the giant computers, IBM hopes to develop films of billionths of square-inch area that would operate at speeds of billionths of a second. If these investigations are successful, IBM's mammoth computers may be reduced to the size of a basketball.

Chemicals

Net profits after taxes of the chemicals and allied products industry increased by almost $10-million between the fourth quarter in 1958 and the first quarter in 1959. Capital spending for plant and equipment expansion has declined by some $100-million in 1959 as compared with 1958.

The output growth of plastic resins was sharp. In the first six months of 1959, as compared with a like period in 1958, the output of vinyls rose by 50%, styrene 40%, and polyethylene by 35%.

Activation analysis is a new tool for chemical researchers. Small laboratory-type neutron generators, if designed to produce high neutron flux, could find a sizeable market in research laboratories. Tracer analysis provides a high degree of sensitivity at reasonable cost.

Radiation chemistry is becoming a real bonanza to some companies entering this new field, notably Raytherm Inc., the stock of which has doubled in six months.

Using electron beam generators, Raytherm specializes in experiments dealing with polyolefins. Principal efforts are directed toward developing high-temperature, flame-resistant insulation for wires and cables.

A new crab grass killer has been developed at Purdue University for the Vaughn Seed Co., which expects sales to climb sharply next summer.

The new compounds, either arsenic- or chlorine-based, are related to the well-known family of chlordane weed killers. Applied directly to the soil when crab grass begins to germinate, its roots absorb the poisons so that it is starved out before attaining any size.

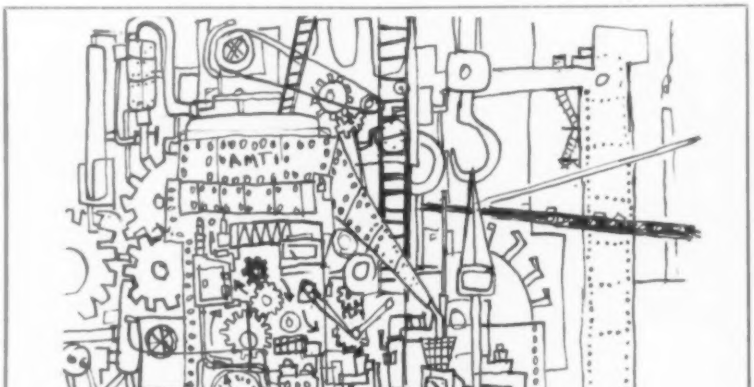
Natural rubber modified with thiol acid becomes more resistant to crystallization, Army research has found. It has essentially the same properties as natural rubber but the elastic recovery is far superior.

A new catalyst developed by Dunlop Research Center is capable of polymerizing propylene with isoprene. Of profitable interest to plastic resin manufacturers, the resulting products can be obtained with isoprene contents up to 50%.

Nuclear energy

While enthusiasm for nuclear power is somewhat dampened by recent discoveries of oil and gas in Africa, and by the abundance of domestic supplies, improvements in technology continue at a fast clip. Expected advances in the fuel cycle show great promise.

Fabrication cost of fuel elements is expected to decline and exposure time to increase in the case of boiling water reactors. Indications are that 50% cost reductions in the next five years are achievable. Increase in exposure time may go up by 30 to 50%. This two-pronged attack would bring



"Don't worry, it'll pay for itself in 20 years."

nuclear power much closer to the competitive threshold with conventional fuels.

Pending breakthroughs, civilian atom power plants (under construction or definitely planned) have reached the lowest point since 1954, when industry was allowed to enter the "peacetime" field. Reasons given are a wait-and-see attitude on the part of buyers, overcrowding of the industry, and slow development of the anticipated European market. None of the eight concerns in the business is making money, and profits are not expected until the late 1960s.

Yet several reactor manufacturers today are willing for the first time to guarantee plant cost, capacity, and fuel consumption. And according to Gwilym A. Price, Westinghouse chairman, "Large nuclear power plants of a proven type now can be built which will produce electricity in some high fossil fuel cost areas at a cost competitive with conventional plants."

For the present, General Dynamics Corp., North American Aviation Inc., General Electric Co., Allis-Chalmers Mfg. Co., Babcock & Wilcox Co., Westinghouse Electric Corp., Combustion Engineering Inc., and Power Reactor Development Co. (a group headed by the Detroit Edison Co.) must maintain R&D programs and keep technical personnel by subsidizing them with other operations and with government help.

The firms are not willing to drop out and forfeit their investments in anticipation of a $2-billion industry estimated for the 1970s or '80s.

With power reactors well on the road towards success, nuclear scientists now are turning toward other uses of reactor products. The AEC has contracted with Sargent & Lundy to design a low-pressure process heat reactor for experimental conversion of sea into fresh water. This supplements present contracts with Fluor Products Corp. of Whittier, Calif. The S&L reactor will be located in southern California, and if proven successful is expected to find many applications in various industries where process steam is needed.

A General Dynamics gas-cooled nuclear system seems to lead in the race to find an economical replacement for oil-fired merchant ships. Savings in operating personnel as well as fuel are inherent in the automated system. The present nuclear freighter *Savannah* uses a water-cooled reactor.

The projected requirements of separated fission products give promise of rapid growth to the fuel processing industry. Demand for strontium, according to the AEC, is expected to increase by more than 50 times in the

next five years; use of cesium may more than double.

Radiation energy for the process industries is another challenge to nuclear researchers, but one which may be grossly overrated in terms of competitive applications in the near future. (See *A New Look at Nuclear Radiation Energy* in the next issue of I•R.)

At least nine companies now are manufacturing particle accelerators for industrial application: High Voltage Engineering Corp. (top producer with some 40% of the world market), General Electric, Varian Associates of Palo Alto, Nuclear Chicago Corp., and Applied Radiation Corp. (privately held); Metropolitan Vickers and Vickers Armstrong in England, Siemens & Halske in Germany, and Phillips in The Netherlands.

Present sales are somewhere around $20-million, but as increasing use is made of radiation energy as an industrial tool, sales could climb to $75-million by 1965.

Metals

Until recently a laboratory curiosity, yttrium has been so improved that GE scientists feel it may become useful in nuclear aircraft engines. Yttrium has low neutron absorption, good strength, and low density. At high temperatures it retains large amounts of hydrogen.

The metal can be used alone or as an alloy. High purity — another attribute for nuclear reactors — has been achieved. (Lindsay Chemical Division of American Potash & Chemical Corp., chief producer of yttrium, guarantees large quantities to be 99.99% pure.) Yttrium will have a promising future in atomic airplanes.

Steel companies, which have been moving more and more into the concrete construction market with their once-useless byproduct, slag, now are entering more glamorous fields.

Blast furnace slag has been used as an aggregate for portland cement and masonry, bituminous surfacing for nonskid highways, road fill, railroad ballast, and rock wool for insulation.

Slag as raw material for fiberglass and fertilizer is next, according to steel research men. For these uses the chemical composition of slag will have to be controlled more closely; it now varies from furnace to furnace depending on proportions of raw materials and operating procedures.

Some 35-million tons are produced yearly — a rate of about half a ton of slag per ton of iron. U.S. Steel's budget for slag marketing doubled in 1959 and will double again this year.

—George Perazich
I•R Washington staff

FACTS you should know about commercial uranium

Outmodes many present metals and methods—safely and at low cost

What is Commercial Uranium?

Commercial (depleted) uranium contains the uranium isotopes that remain after the removal of U-235 (with a week's radiation exposure only about 1/10th to 1/100th the radiation received from an ordinary chest X-ray). It is useful in a variety of industrial applications.

Uranium has many interesting properties.

For example, Davison Uranium has exceptional density —*68% greater than lead* and about equal to gold. This indicates usages as counterweights in aircraft, shipbuilding, tool making industries—wherever high weight and low volume are factors. It alloys readily with many metals including aluminum, chromium, copper, iron, manganese, molybdenum, niobium, nickel, silicon and zirconium. Corrosion resistance is increased when uranium is alloyed with one of these metals. Davison Uranium possesses high tensile strength and low thermal expansion. While fairly hard (Brinnell 240) at room temperature, uranium becomes very malleable as temperature rises. At 1100° F. its hardness drops to about 20.

Is Davison Uranium easy to fabricate?

Davison Uranium may be melted and cast into any desired shape. It may be formed by extrusion, drawing, rolling, swaging, pressing or forging.

You can machine Commercial Uranium with conventional carbide-tipped machine tools, bearing in mind that it has work-hardening characteristics similar to those of stainless steel.

It is necessary to machine uranium under water soluble lubricants. Commercial Uranium has been machined on a number of tools including lathes and automatic screw machines, saws, high-speed mills and centerless and surface grinders.

How about welding?

Success in welding Davison Uranium has been achieved using the Heliarc and shielded arc-consumable electrode process. At this date experiments continue in joining uranium to uranium by brazing or soldering.

How has Commercial Uranium been used?

Present applications include shielding materials, telatherapeutic heads, isotope containers; as counterweights and static balances. And, for many years, as coloring agents and glazes.

Is Davison Uranium safe?

Radiation exposure is virtually non-existent. AEC Tests indicate that a person can work week after week with depleted uranium without exceeding recognized radiation exposure levels.

However, just as other heavy metals such as lead are toxic if breathed, care must be exercised to avoid inhalation of dusts. A properly ventilated work area removes this dusting problem.

Must special storage precautions be taken?

Uranium metal (except fines) can be *handled and stored with methods similar to those used with any other massive metal.* Fines, however, are flammable and should be stored under oil or water.

Is Commercial Uranium expensive?

Not at all. For example, in lots of 1400 pounds or more Commercial Uranium is priced at just $4.60 per pound —considerably cheaper than other heavy metals, with the advantage of superior density.

Need more information?

A letter will bring you additional details for the application of Commercial Uranium to your products or processes. Write today to Department C-101, Erwin, Tennessee.

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W. R. GRACE & CO.
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The paper you are looking at, and your shirt tomorrow . . .

The research dream of attaining inexpensive fabrics for throwaway clothing and other disposable uses has been carried several steps closer to reality. Nonwoven fabrics, special papers, and plastics are being tested daily in an attempt to find a practical, yet cheap, material. The following article, which explores some of these materials and their requirements, has been printed on an extensible (stretchable) paper called Clupak. Clupak's stretchability lets it absorb shocks and strains that rip or tear other papers. You can't wear Clupak now—but one day you may.

Throw awa

EVER SINCE THE PAPER NAPKIN, the paper towel, and the paper facial tissue introduced Americans to disposable fabrics, people have been looking forward to the day when most products now made of cloth could be made cheaply of some other material and be thrown away after being used once or twice.

Industry and consumers have benefited from the convenience of being able to blow their noses, clean their machines, and wipe their hands with products consigned immediately to the garbage pail. The success of these disposables has led to predictions that some day we would stuff soiled bed sheets into waste baskets instead of hampers, sleep in tents that could be burned instead of laboriously repacked, and wear clothes only once.

Clothes come later

New disposable fabrics have been arriving slowly and gaining acceptance equally slowly. The throwaway bed sheet and the throwaway tent are with us now. Other disposables are already on the horizon. Some things, like clothes and materials that require complex fabrication, are likely to come somewhat later.

Disposable fabrics are inevitable because they are convenient. The advantage of not having to sort, clean, repair, iron, or sterilize has a strong appeal to liesure-loving consumers and cost-conscious industrial users.

Just what constitutes a disposable? A product is

y your clothes

Attempts to make disposable fabrics that are cheaper to throw away than launder include spraying a new liquid raw material on a dress form, creating special rubber and plastic, and tearproofing–even waterproofing—paper.

by **Albert A. Atwell,** *president Corporate Research Inc.*

truly disposable when it is cheaper or almost as cheap to throw away than to launder it for reuse. Thus, disposability is a function of price.

How free is 'cheap'?

You have the ultimate in disposability when you have what economists call "free goods." Disposability becomes complex when the material is not free. Then you have to balance cost of materials, cost of design, and ability of the product to serve its purpose.

However, certain situations require disposability unhampered by price. Contamination—biological, chemical, radiological, etc.—necessitates throwing away a garment or sheet whether it's as cheap as paper or as costly as cashmere.

The principal reason why disposability is moving closer is the appearance of a multitude of new materials, in particular specially developed papers and non-woven fibers. One experimental product called "Dura-Weve," produced by Scott Paper Co., consists of paper layers reinforced by a high-strength network of rayon and nylon threads.

High-speed laminates

Variations in treatment, such as water repellants and fire retardants, paper stock, and plastic film laminates, make these materials extremely versatile. For example, a sheet consisting of a film of plastic on one side and paper on the other is now available for hospital use. The material prevents transmission of infectious organisms from one surface to another, yet body fluids are still absorbed in the paper layer. The laminate is relatively inexpensive because it is produced on high-speed machinery.

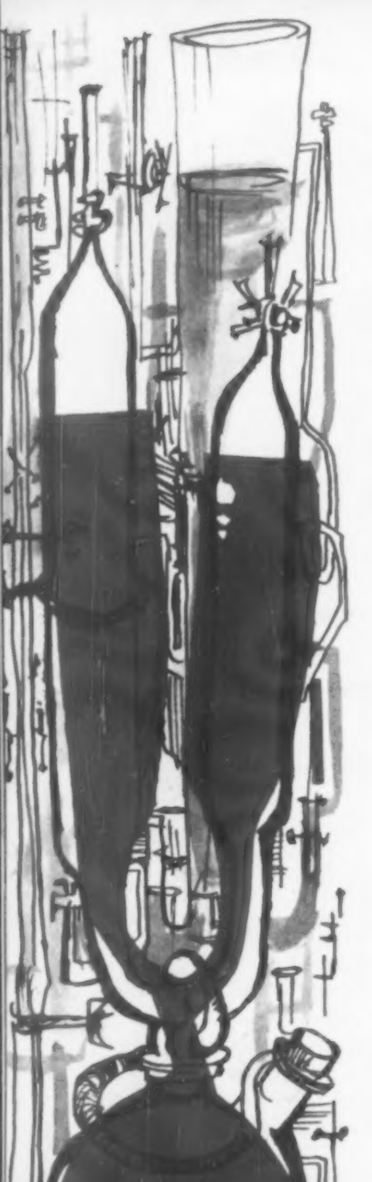
The University of Michigan hospital is trying something along these lines as part of its standard bed makeup. A sheet of polyethylene film sandwiched between two sheets of paper is replacing both bed pads and bottom sheets.

Dura-Weve and other reinforced celluosic materials, such as Kimberly-Steven's "Kaycel," are being used in a variety of successful ways—including linens, industrial clothing, tents and toys, headrest covers, hand towels, place mats, industrial wipers, and obstetrical kits.

A second source of material for future disposables may be "Clupak," a new stretchable paper now manufactured in kraft grades under license by Clupak Inc., the trademark and patent holder. Clupak has a built-in extensibility, or stretch, which lets it absorb shocks and strains that cause ordinary paper to rip, tear, or puncture. Thus, the material becomes stronger and tougher, yet softer and more flexible than conventional paper.

Go ahead! stretch this page

To illustrate the characteristics of the material, this article has been printed on bleached converted Clupak kraft paper, made by International Paper Co.



The flexibility and drapability of the paper is apparent even at a low stretch level (8 to 10%).

Clupak's high tensile strength was an unexpected advantage. During an early production run of particularly heavy Clupak a workman attempted to tear off a sample of the paper for weighing. When he had to reach for a knife, the paper makers knew they had something.

By imparting higher stretches to the paper, radical changes in normal paper properties can be made to take place, opening the way for Clupak as a textile substitute. Current research indicates that it can be made to look and feel like fabric, and can be printed, buttoned, sewn, and made flame-resistant or sterile.

Despite Clupak's unusual properties, it is produced by an extremely simple, why-didn't-I-think-of-it mechanical process, invented by Sanford L. Cluett, originator of the shrink-resistant process behind the "Sanforized" trademark. A wet paper sheet is compressed between heated steel rolls and a rubber blanket, which flows when compressed against the sheet. The first unit was put in production by West Virginia Pulp & Paper Co. in 1958.

Random webs of fiber

Non-woven fabrics, the second major group of materials showing promise in the throwaway field, are random webs of natural or synthetic fibers impregnated with a bonding agent without weaving. A typical non-woven material is "Masslinn," produced by Chicopee Mills, a subsidiary of Johnson & Johnson. A similar material is being made by St. Regis and Kimberly-Clark paper companies.

The non-woven fabrics resemble conventional woven materials more closely than disposable paper fabrics. Yet each is different and each represents an attempt to develop new materials cheap enough to be used in throwaway products.

It would be impossible to present all of the disposable products on the market today, but a sampling will illustrate the existing state of the art.

As suggested previously, the medical field has responded strongest to the advantages of disposability and offers the most promising field for further progress.

One item currently in widespread use is the throwaway, presterilized obstetric linen pack, which contains all the linens needed for completing one delivery. Disposables also serve the medical profession in the industrial dispensary. In a factory medical center, linen usage is not usually large, but in treating industrial accident cases the linens frequently are soiled from workers' clothing, body fluids, and drugs. Disposable sheets and pillowcases have eliminated both laundry rental and replacement purchases.

Water-repellant nurses

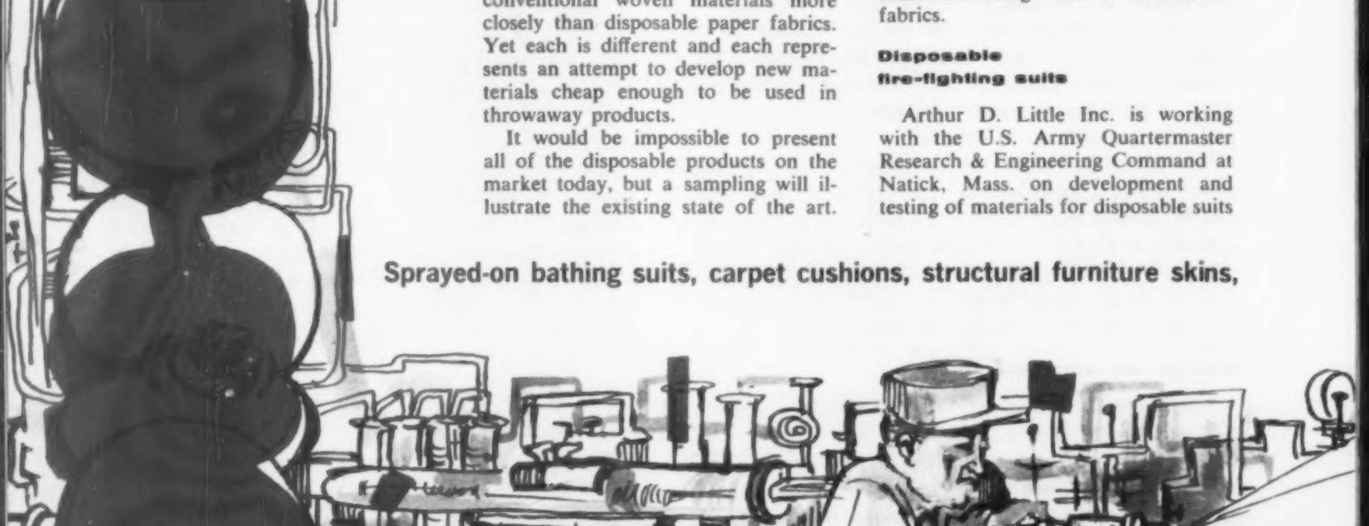
The factor of appearance enters the picture in hospitals; nurses and other white-clad workers must have spotless uniforms. Single-use garments are free from discoloration, stains, and tears. Williamson-Dickie Mfg. Co. sells disposable white laboratory coats and coveralls of Kimberly-Steven's non-woven Kaycel, which is made of paper lined with nylon fibers. The garments are water- and fire-resistant and cost from 50 cents (for laboratory trousers) to 75 cents (for lab or shop coat). Semi-disposable plastic gloves for housewives also are being sold, for 68 cents.

Corporate Research Inc. will market Kaycel tents, sleeping bags, and women's raincoats which may be thrown away at the end of the season, eliminating the need for winter storage. Also for the consumer, draperies, sewing patterns, shoe innersoles, towels, polishing cloths, lamp shades, dolls' and children's clothes, and costumes are being made of non-woven fabrics.

Disposable fire-fighting suits

Arthur D. Little Inc. is working with the U.S. Army Quartermaster Research & Engineering Command at Natick, Mass. on development and testing of materials for disposable suits

Sprayed-on bathing suits, carpet cushions, structural furniture skins,



Binders for nonwovens and their suppliers . . .

AMERICAN FELT CO., Glenville, Conn.	*Windsor felts, Feutron*
AVONDALE MILLS, Sylacauga, Ala.	*Plastavon, industrial and household wiping materials, padding, and backing*
BURESH NONWOVENS, Westfield, Mass.	*low-density filter mats, padding and filler materials*
CALLAWAY MILLS, LaGrange, Ga.	*Callon, industrial and household wiping materials*
CHICOPEE MFG. CO., Milltown, N. J.	*toweling, draperies, sanitary products, interlinings*
C. H. DEXTER & SONS INC., Windsor Locks, Conn.	*tea bag papers*
DRY COR FELT CO., Staffordville, Conn.	*industrial felts*
THE FELTERS CO., Boston, Mass.	*Allfab felts*
GUSTIN-BACON MFG. CO., Boston, Mass.	*rug padding material*
JOHNSON & JOHNSON, New Brunswick, N. J.	*Masslinn, Flairform, Surgine, Keybac*
THE KENDALL CO., Walpole, Mass.	*Webril, filter materials, heat sealable bags, electrical insulation*
KIMBERLEY-CLARK, Neenah, Wis.	*Kaycel*
LOWNDES PRODUCTS INC., Greenville, S. C.	*Kreme-Kleen, industrial wiping cloths*
MINNESOTA MINING & MFG. CO., St. Paul, Minn.	*Mistlon, Sasheen, decorative ribbons and tapes, electrical insulation*
PELLON CORP., Lowell, Mass.	*Pellon, interlinings and vinyl backing materials*
RAYBESTOS-MANHATTAN INC., Manheim, Pa.	*Pryotex*
ROCK RIVER COTTON CO., Janesville, Wis.	*disposable bibs, towels, industrial wipers*
SACKNER PRODUCTS INC., Grand Rapids, Mich.	*padding, cushioning, automobile insulation, furniture, millinery, caskets*
SCOTT PAPER CO., Chester, Pa.	*Dura-Weve*
STAR WOOLEN CO., Cohoes, N.Y.	*Ny-su-loft*
STEARNS & FOSTER, Lockland, Ohio	*Fabray, milk filters, vinyl backing materials*
TROY BLANKET MILLS, Troy, N.H.	*Troybelt*
WEST POINT MFG. CO., West Point, Ga.	*Lantuck, Interlon, backing materials for resin coatings*
WOOD CONVERSION CO., Cloquet, Minn.	*Tufflex*

Manufacturers of non-woven fabrics and their products . . .

ACETATE	*Celanese, Eastman Chemical Products*
ACRYLIC	*American Cyanamid, Chemstrand, Dow, du Pont, Eastman Chemical Products, B. F. Goodrich, Union Carbide*
POLYAMIDE	*Allied Chemical, American Enka, Chemstrand, du Pont, Industrial Rayon*
POLYESTER	*du Pont*
VISCOSE	*American Enka, American Viscose, Courtaulds, Industrial Rayon, North American Rayon*

Nonwoven chemical fibers and their suppliers . . .

ACRYLATES	*B. F. Goodrich, Rohm & Haas*
BUTADIENE-ACRYLONITRILE	*B. F. Goodrich, Goodyear Chemical Division, International Latex, U.S. Rubber Naugatuck Division*
BUTADIENE-STYRENE	*Dow Chemical, B. F. Goodrich, Goodyear Chemical Division, International Latex, Koppers, U.S. Rubber Naugatuck Division*
POLYVINYL ACETATE	*Borden Chemical, Celanese, Dewey & Almy, du Pont, B. F. Goodrich, National Starch Products, Wica Chemical*
POLYVINYL CHLORIDE	*Borden Chemical, B. F. Goodrich Chemical, Goodyear Chemical Division*

insulation—you-name-it—are being made in the laboratory with new rubber and plastic materials.

for firefighters. The material is heat-reflective and water-resistant. Suits and uniforms for the Army will be made from these and other disposable materials for tests in training maneuvers. Doctors and nurses at Ft. Sam Houston are wear-testing disposable surgical caps, gowns, masks, boots, and bibs.

Disposables also have made headway in certain industrial applications, although industrial use of disposables, especially garments, still is limited. Many food-handling plants, stores, and food-serving areas are finding that a disposable apron can match or beat the cost of a cotton apron after buying or renting and inventorying are taken into account. At present, most widespread applications in industry are as backing filters, wiping rags, painters' drop cloths, and for bagging and packaging.

Throwaway fabrics are likely to make their greatest headway in areas where there is a minimum of fabrication. This means that we will be sleeping in paper sheets long before we'll ever wear paper clothes, despite the fact that disposable clothes are the glamorous goal of all disposability researchers.

DISPOSABLE UNIFORMS *under test at Fort Lee, Va. are one application of throwaway fabrics. These are made of paper.*

Throw away your sewing machines

The problem of clothing is simple: it costs too much. Unfortunately, almost all the cost of making shirts, coats, and trousers goes into cutting and sewing. The material in a disposable garment is cheaper than the same amount of cotton, but as long as the fabrication methods are the same, the cost of the finished item will not be sufficiently lower to make the product commercially competitive.

As long as disposable clothing is styled and sewn like reusable clothing, it won't be competitive in price. Only when disposability is a must (as in some medical and industrial applications) does the cost of fabrication assume a minor role in the total picture.

Some firms that make clothing and other fabric products now use the new low-cost materials to make garments by non-sewing methods. Usually these involve the use of a film or tape which is placed between the joints and heated under pressure to produce a bond.

The method is adaptive to continuous operation on a machine similar to a sewing machine, but it does not represent a saving over conventional sewing. Chief advantage is that it eliminates perforations that might weaken the materials, and seals any undesirable openings, such as in waterproof garments. These methods produce ultra-high-strength bonds, but they do not solve the basic problem of providing low-cost, high-volume production of disposable garments.

A new approach to the disposable garment is needed. We won't enter the age of throw-away clothes through some occult process of "product evolution." We are now on the threshold of a whole series of fabrics to replace cotton, wool, and synthetic fibers at a fraction of the present prices. But there is no future in substituting a superpaper at 11 cents a yard for cotton at 20 cents when the finished garment of either material will cost the same.

Spray on your clothes

One solution to the production problem was tried a few years ago by Cambridge University and Arthur D. Little Inc., with "sprayed-on" nonwovens. Chemists aimed a spray-gun at a mannikin and quickly "created" a rubber-fiber bathing suit. Spray-on girdles and rug underlays also were tested. The rubbery fabric has the elasticity of sheet rubber, but is porous and retains its shape. The rubber fibers are formed by forcing a solution through a high-pressure nozzle spray. Similar process one day might prove feasible for paper nonwovens.

A brilliant future awaits the company or individual who is first to solve the fabrication and design problem, thus bringing on the economical stuffing of our clothes into the wastebasket.

Meanwhile, possibilities in disposables are much nearer realization in other areas. For instance, there is still a large untapped field for disposability in sleeping bags, shower curtains, covers for cribs and playpens, bibs, diapers, etc. Other excellent disposability candidates are linen for hotels, motels, trains, and factories since part of the expense of curtains, sheets, towels, and pillow-cases is their loss through petty larceny.

The future predicted for disposability, though sometimes prematurely enthusiastic, is inevitable. The fact that it is predicted so often helps make it so: with each appearance of a new material that lends itself to disposability, new effort and imagination are put into developing the field. To a limited extent we already are well within the throwaway era. Its full realization is only a matter of time — and creativity. ■

New Foote Lithium Metal Dispersion . . . so reactive that it bursts into flame on contact with cold water. Light for the photo was supplied by the reaction.

NEW HIGH-REACTIVITY LITHIUM DISPERSIONS

Foote's new form of Lithium Dispersions realizes the high catalytic assets of lithium metal, lithium hydride, and lithium butyl . . . permitting faster, more complete, more controlled reactions.

AVAILABLE IN SEMI-COMMERCIAL QUANTITIES

Lithium Metal Dispersions:
bulk lithium dispersed in hydrocarbons.

Lithium Hydride Dispersions:
lithium dispersion hydrided in the dispersed state in hydrocarbons.

Lithium Butyl Solution:
prepared by the reaction of butyl chloride and lithium metal. Available in various solvents, such as hexane and pentane.

No oxygen, please! Foote's new process prevents the formation of activity-reducing coatings. X-ray analysis indicates that the surfaces of the dispersed metal are *clean* and *free* of hydroxide, carbonate, and oxide.

Small, uniform particle size makes the lithium metal and lithium hydride much more reactive than the usual forms. The small particle size facilitates reaction with the *whole* particle even if insoluble reaction products are formed. The uniform size means that *all* the metal will be used.

A more complete technical description of these new lithium dispersions is just off press. This literature and samples are available upon letterhead request to Technical Literature Department, Foote Mineral Company, 480 Eighteen West Chelten Building, Philadelphia 44, Pennsylvania.

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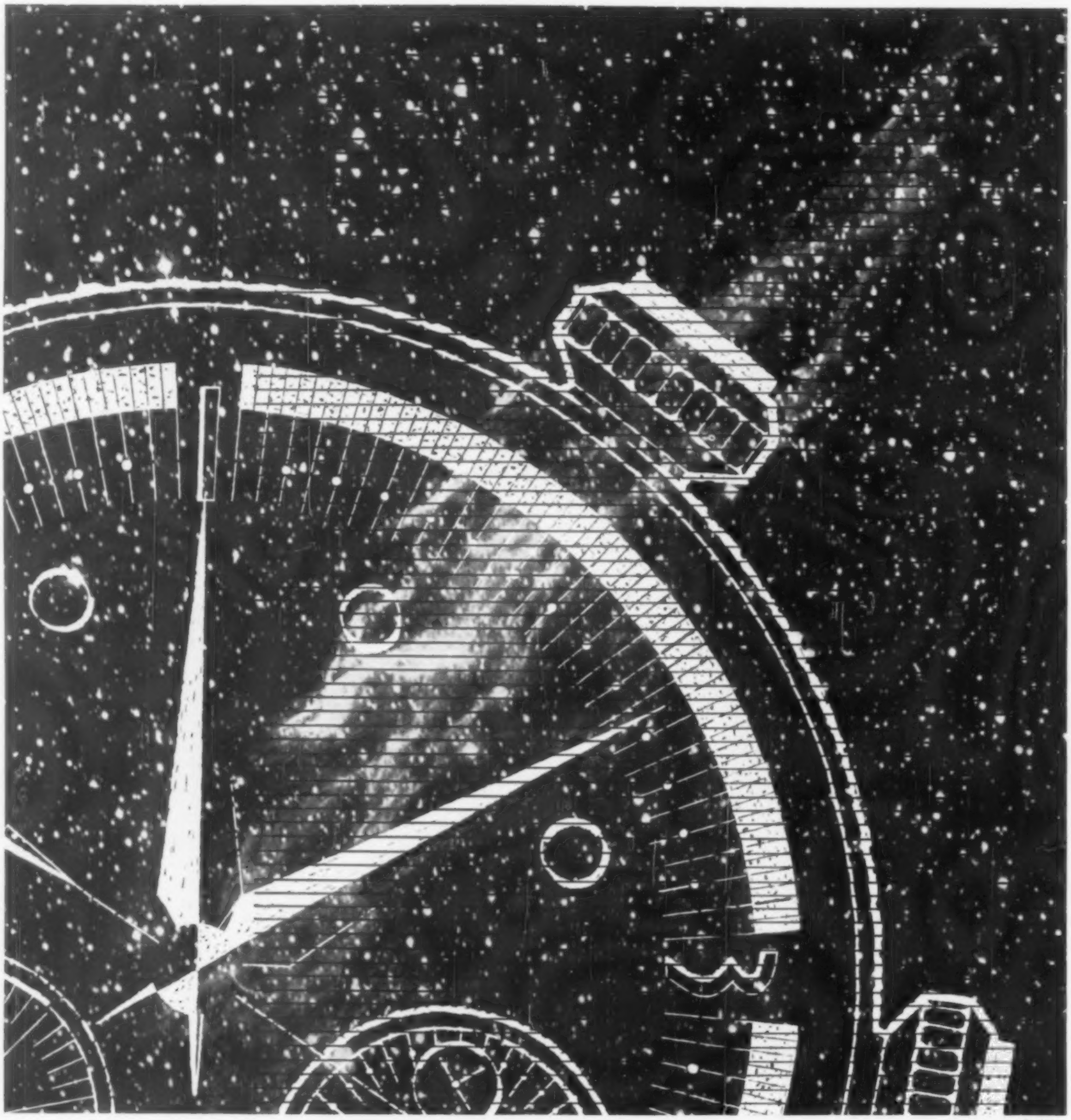

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RESEARCH

TRENDLETTER

February, 1960

Dear Sir:

Engineers and scientists are unhappy, underpaid, and in demand, according to a survey by Opinion Research Corp, Princeton, N.J. The organization interviewed 622 scientists and engineers and 105 managers in the aircraft, drug, chemical electrical and electronic equipment, petroleum, and rubber industries.

Seventy-two percent complained that management misused the engineers' talents; 71% said companies forced them to over-specialize; and 67% commented that getting ahead in management was more a matter of politics than of ability. Almost all claimed they were underpaid.

Another study, by Dr. Russell L. Ackoff of Case Institute of Technology, Cleveland, revealed that chemists average 16½ hours a week in scientific communications, 6.7 hours a week in business communications, and only 16 hours per week in working with scientific equipment.

electronics

◄A new electronic generator with no moving parts is designed to convert rocket exhaust heat directly to electric power in order to power control mechanisms, telemetering, and other equipment in a missile. Developed by Hunter-Bristol Div. of Thiokol, and RCA, 30 Rockefeller Plaza, NY 30, the 3½-pound device has produced up to 270 watts (almost 80 watts per lb), and has been successful in tests with both simulated and actual rocket heat sources.

The thermionic tube is a hollow cylinder which fits over the rocket-flame tube. Electrons are "boiled" out of the cathode and into an electrode, where they produce an electrical output.

◄A photo-interpretation method which pinpoints all terrain features reflecting the same amount of radar radiation has been announced by Goodyear Aircraft Corp, Akron 15, Ohio. "Image-density isolation" allows scientists to select and emphasize all areas in a photograph having a single density or grayness.

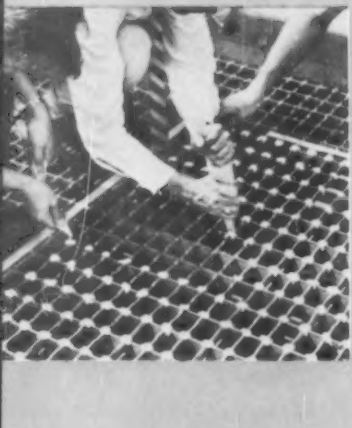
Present densitometer method allows investigation of only a small area of the photograph. The new technique gives a picture in which predetermined shades of gray, corresponding to specified light or energy levels, are emphasized and visible to the naked eye.

◄A technique for successful floating zone melting of boron will provide larger crystals of this semiconductor for research than previously available. In the technique, developed at Bell Telephone Labs, 463 West St, NY 14, boron powder is boiled to dryness in boric acid. The granules, coated with boric acid, can be pressed into forms and handled without breaking. The bars then are heated under vacuum to decompose the boric acid into boron oxide and bond the powder into a strong bar. Previously boron could not be zone melted because of the extreme friability of pressed bars.

chemistry

A thin film coating for silicon solar cells, developed at Bausch & Lomb Optical Co, 635 St. Paul St, Rochester 2, NY, provides the first effective "cooling" measure for increased efficiency and longer life of satellite electronic systems.

Solar batteries use only about 10% of the sun's energy; the remainder heats the cells and the satellite itself, inhibiting radio transmission, or even destroying it by melting soldered contacts. The film—composed of magnesium fluoride and silicon monoxide—re-radiates long "heat" waves into space, but admits the shorter, power-producing waves.



◄Small blobs of plastic and grit have cut skidding accidents from 35 a year to zero on the steel grid of a California bridge. The mixture contains emery, which provides extra traction, and epon resin, a plastic adhesive developed by Shell Chemical Corp, 50 W 50th St, NY 20.

Epon bonds to steel with about the strength of a weld. The mixture is applied to cross points of the grid, which can become as slick as ice in wet weather.

The gasoline bricks carried by Russian scientists on IGY expeditions are composed of a highly concentrated solid emulsion of 95% gasoline trapped in honeycomb cells. Addition of formaldehyde and other chemicals increases viscosity, and the mixture is pressed into strands and cut into briquets. These are broken up before use and the gasoline squeezed out with less than 3% loss.

nucleonics

Advances in smaller neutron generators and fast radiochemical separation methods promise to make activation analysis a common nuclear tool in the small laboratory. Activation analysis consists of chemically separating an irradiated sample, measuring the element's activity with a gamma-ray spectrometer, and correlating this with a known standard.

Deterrents to widespread use of the accurate tool have been the scarcity of high-energy sources and time involved in separation. Lab-sized generators, under development at High Voltage Engineering, Nuclear Chicago, Schlumberger, Texas Nuclear, and Kaman Aircraft, will make the process available within the year for $20,000.

Separation time has been cut down on several elements at the University of Michigan, Ann Arbor, so that the isotope can be measured before it has decayed too much.

metallurgy

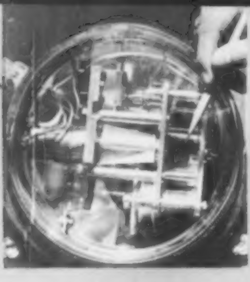
Several advances have been made in high-purity metals research. The first successful extrusion of pure chromium metal tubing is considered a prototype production technique in achieving ductile chromium—potentially an excellent structural material. After alloying, pure ductile chromium could incorporate high-temperature strength (1500—2000 F) with corrosion and oxidation resistance.

◂ In the experiment at Nuclear Metals Inc, Concord, Mass., chromium powder was cold-compacted in a mild steel container, heated, placed in a 1,000-ton press, and extruded over a mandrel (see photo). The resulting chromium tubing was almost perfect in form, and close to the theoretical density of pure chromium.

air and space

Development of the hydrogen pump at Aerojet General Corp's Liquid Rocket plant, Sacramento, Calif, makes feasible the construction of space engines with half a million pounds of thrust using available hardware. According to Aerojet researchers the pump is the last breakthrough needed in paving the way for powerplants up to 10-million pounds thrust.

Once we get them up there, satellites will be able to take a continuous strip of weather pictures around the world and broadcast it as television



signals to the ground in 5 to 10 minutes, with the development of an electronic space camera by RCA, 30 Rockefeller Plaza, NY 20.

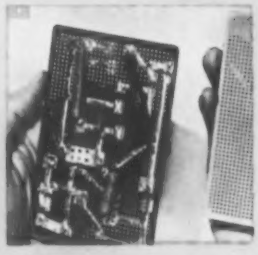
◄ The camera is a combination of a special electrostatic tape (indicated in photo) and a conventional TV electron gun. It is simple and durable, with reduced sensitivity to radiation and widely variable speeds of operation. It has a large picture capacity, based on the ability to erase and re-use the tape after each passage.

now available:

◄ Jet ground support . . . Mobile, self-propelled power plant is designed for servicing jet aircraft. Highly maneuverable, its generator will power pure jet, prop jet, or piston types, has application in construction, pipeline, chemical, military, police, firefighting, and other operations. Steward & Stevenson Services, 4516 Harrisburg Blvd, Houston.

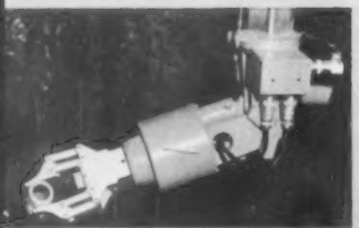
◄ Optical material . . . "Irtran," molded by a new technique at Eastman Kodak Corp, Rochester 4, NY, forms a dome for the nose of an infrared-guided missile. The material transmits radiation efficiently up to 8 microns in the infrared. It is especially resistant to re-entry thermal shock.

Heat exchanger . . . combines high transfer capacity, low fabricating cost, and ease in folding return bends without recourse to brazed, welded, or soldered joints. American Thermocatalytic Corp, 200 E 2nd St, Mineola, NY.



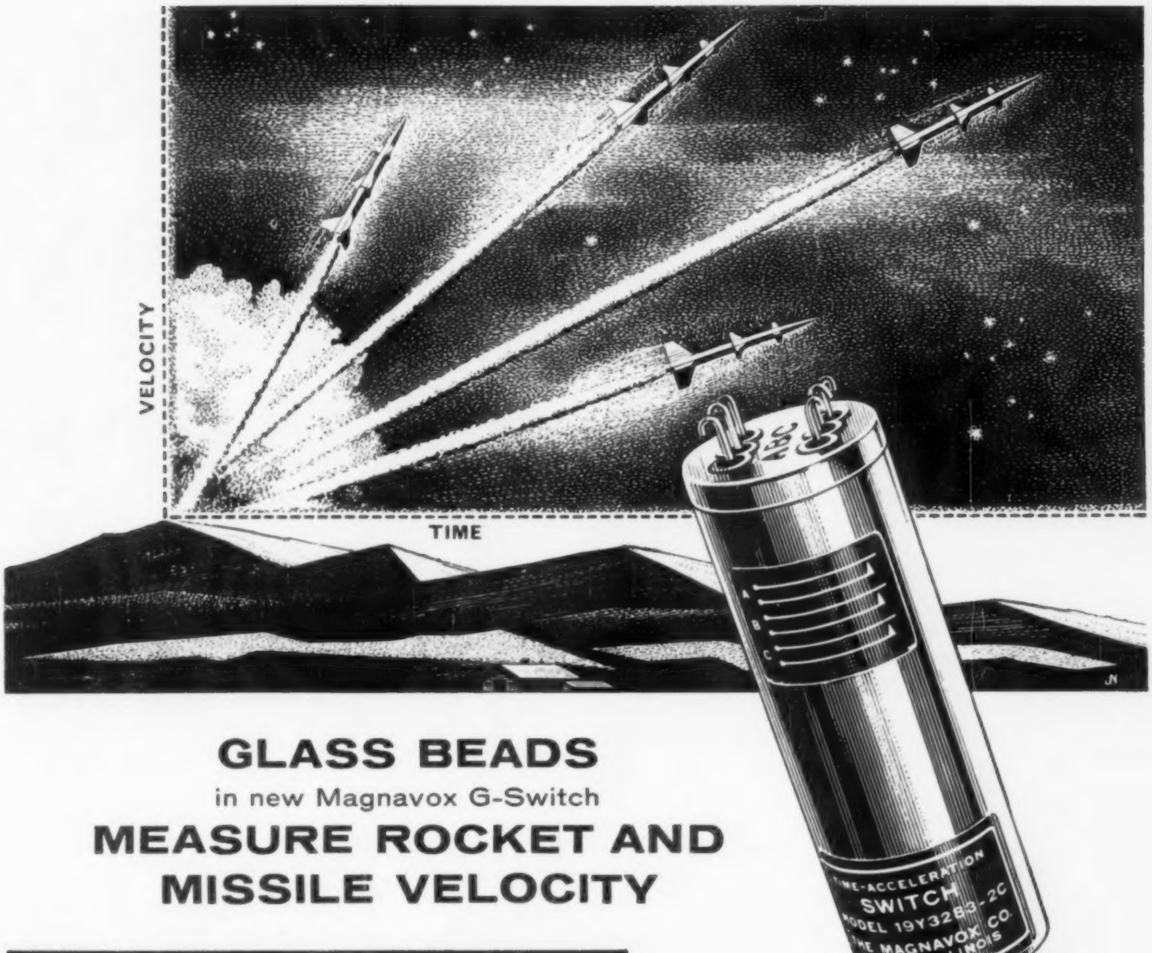
◄ Prototype tool . . . "Fotoceram" grid board allows electronic designers to make their own printed circuit layouts in the lab. The resolderable board is clad on both sides with copper that can be etched away as desired. The grid for installation of components consists of .052-inch round holes spaced 1/10-inch apart on center. No special equipment is needed reports designer, Corning Glass Works, Corning, NY.

Neutron detector tube . . . A photosensitive device which will react to neutron bombardment can be used with standard multiplier phototube circuitry. The 2-inch diameter, high gain, 10-stage, end-window type multiplier tube was developed by Allen B. du Mont Labs Inc, Clifton, N.J.



◄ Economical remote-control manipulator . . . The electro-mechanical device handles up to 200 lbs for use in small labs. General Mills, 1620 Central Av NE, Minneapolis.

—Industrial Research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EDITOR'S NOTE: *There are at least two sides to every controversy. In writing for* Industrial Research, *Dr. Stern knew he was tackling an engineering-management audience whose views on automation for the most part are not shared by American unionism. Your criticisms and comments of his ideas will be appreciated.*

the automation

by **James Stern,** *international representative,*

James Stern, of the UAW National Aircraft Dept. staff, has had many years of direct collective bargaining experience with labor-management engineering, economic, and productivity problems. He served as the executive director of the UAW's automation research committee for two years prior to August, 1956, was a member of UAW Local Three, which represents Dodge plant workers in Detroit, and was appointed to the UAW staff in 1946, holding responsibility for its time study and engineering activities. While on a two-year leave from the union, he served as productivity section chief of the Economic Cooperation Administration's Labor Division in France. Stern also taught at undergraduate and adult education levels. He holds a BS in mechanical engineering from Antioch College and a PhD in economics from the University of California at Berkeley. Stern has worked as an engineer, draftsman, maintenance mechanic, and production assembler for several manufacturing companies.

SINCE THE TERM "AUTOMATION" was coined by a Ford Motor Co. executive more than a decade ago, it has come into common usage on every level from unskilled labor to top management. The word itself now is loaded so semantically, it is a synonym for anything from panacea to doom depending on your circumstances. The cloud of emotion now surrounding automation has obscured its economic implications within our society—obscured it so that worthwhile research into this fundamental issue has been inhibited seriously.

Management was first to proclaim to the public the virtues of automatic and automatically controlled machinery, methods, and processes. Automation was labeled "revolutionary," and we were assured it would increase productivity, save labor, and eventually advance all of mankind.

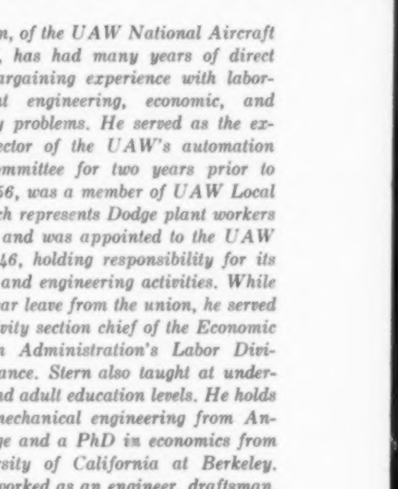
Management, however, did not anticipate how automation might affect labor unions or what their viewpoint would be. So when labor, too, hailed the new technology—and used these same victorious proclamations to support its own claims to a greater share in increased products—management hastily retreated.

Suddenly it was discovered that the phenomenom of automation was more old than new. Others, writing on the behalf of management, played it down, deprecated, or even ignored it. An atmosphere was created, at least in part as a defense against these union moves, which stifled investigation. Although technical research into the automated processes themselves steadily increased, we still know little about what the economic impact of these new techniques may be and how they ultimately will affect the structure of our society.

An "x" in the economy

Like Caesar's Gaul, current research into economic implications of automation is divided into three parts. Each of these, by being too specific, too general, or not totally relevant, has failed so far to establish very much truly basic information about how we can expect our economy to behave with the addition of the unknown factor that is automation.

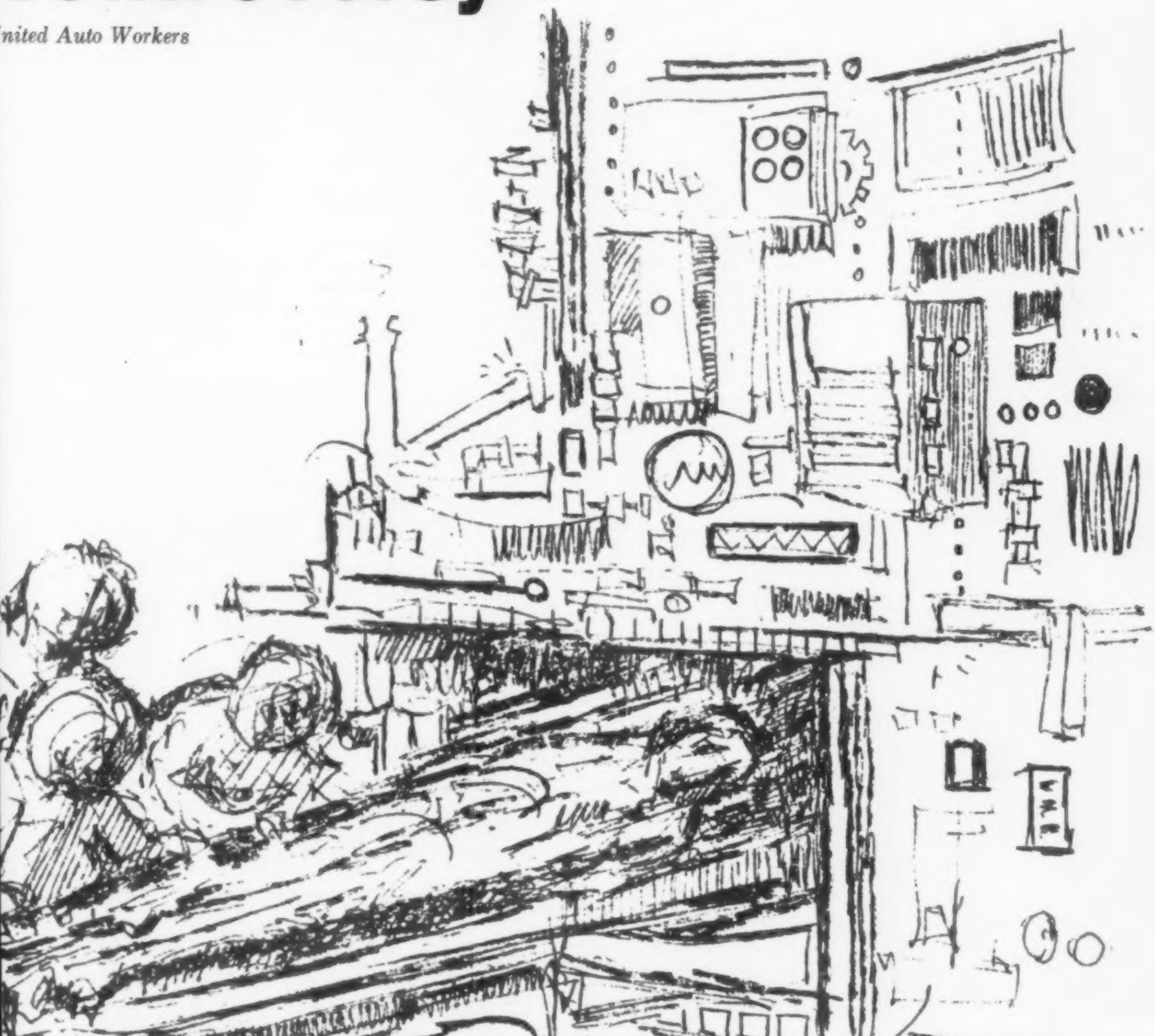
First, there are case studies at the level of the single office or factory. Written generally and optimistically from the viewpoint of management, they imply that a favorable adjustment made in one isolated instance may well pertain to an entire industry. That even the Bureau of Labor Statistics may be guilty of such short sight is implicit in a (continued on page 53)

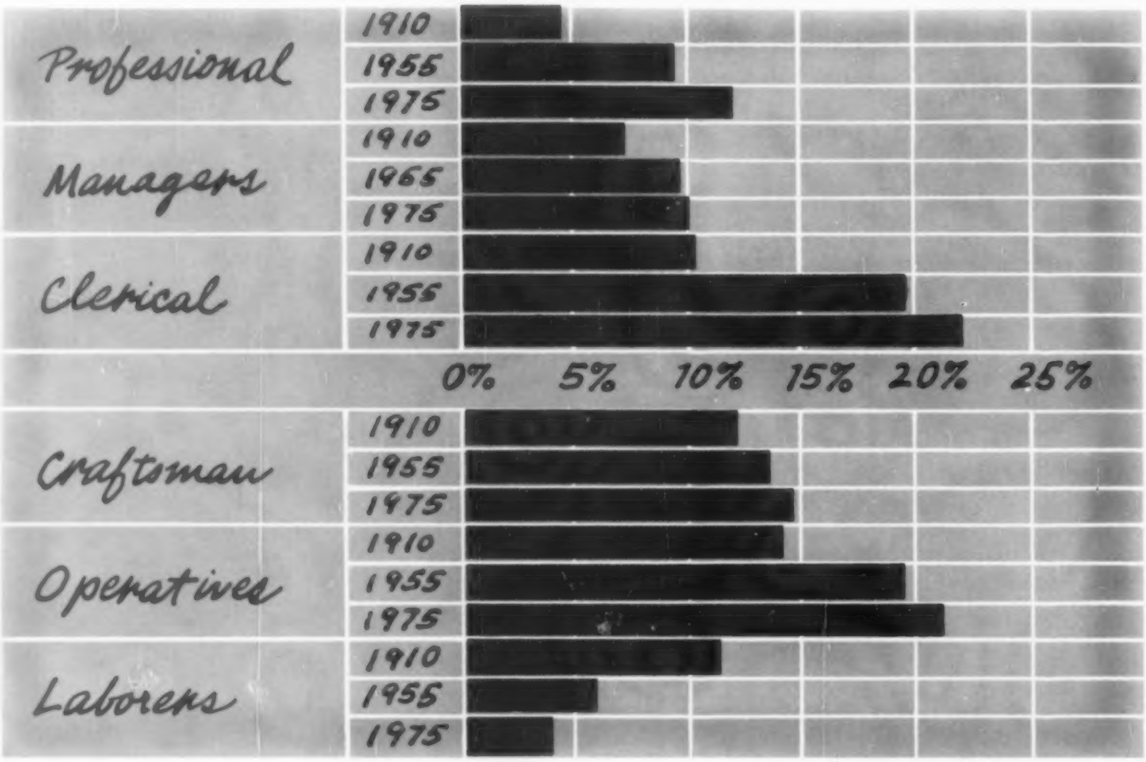


The only thing 'revolutionary' about automation is the degree to which it has encircled management-labor conflicts. Right now it is an unknown factor in the economy, but can benefit both business and labor if clarified.

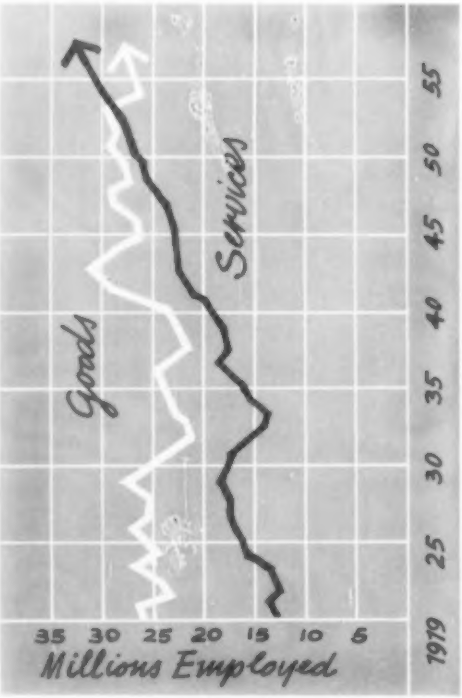
controversy

United Auto Workers

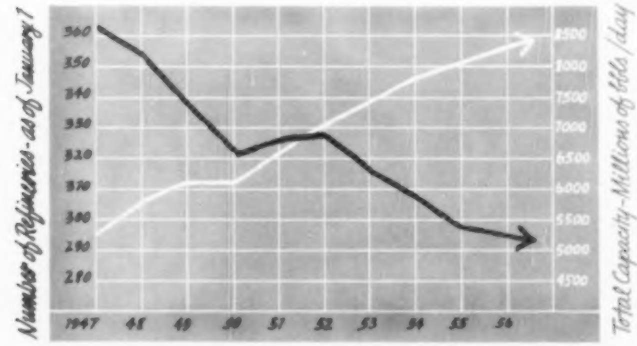




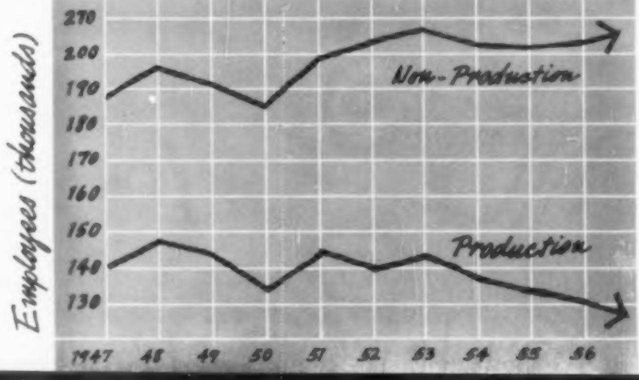
THE GREAT SHIFT *to professional and technical occupations is being brought about because of increased automation in industry. The number of craftsmen and operatives will continue to increase, but probably at a rate slower than the labor force as a whole.*



GROWTH OF SERVICE *industries employment for the past 40 years has been accompanied by relative stability in the goods-producing industries.*



TYPICAL OF CONTRADICTIONS *between statistics and case studies is shown here in figures from a single BLS report. Author cites the decreasing number of oil refineries contrasted (above) with the expansion of barrel production capacity, and, below, the shifting mix from producers to non-producers. Yet the study asserts that automation caused no layoffs.*



recent report entitled *A Case Study of a Modern Petroleum Refinery*, which asserts the usual, sanguine:

"No regular employe was laid off as a result of the (automated) changes."

In the appendix to this same report appear two tables which in part contradict the example and indicate that the overall employment effect of automation in the entire industry may be quite different.

The first table shows that in the 10 years preceding 1957 the number of petroleum refineries decreased, while actual total capacity increased by more than half; the second shows the mix of workers shifting sharply towards non-producers and the projected number of production workers steadily decreasing.

Contradictions between case study results and industry statistics are not unusual, and given the defensive attitudes of management, it is logical to assume that industry researchers simply receive little cooperation or access to data in plants and offices where the picture is not favorable.

The second, and perhaps largest, body of automation literature centers around its psychological and sociological effects. Since these studies do not deal directly with the employment situation, they undoubtedly meet less resistance. Nevertheless, they bring many pertinent economic facts to light, even if in the most oblique fashion.

Is factory loneliness relevant?

Thus, they may study the phenomenon of loneliness in the less-densely-populated automatic factory, or more often, provide relevant material merely as background, as in this quotation from *Toward the Automatic Factory*, by Charles R. Walker:

"The hot mill crews, as we have seen, consist of nine men, in contrast to 20, 25, or more at the old mills. Yet the new mill manned with a crew of nine men is capable of producing four times as much pipe as a mill manned by 25."

Interdisciplinary research certainly would be furthered were the economic implications of this quotation included within the purview of this and similar studies.

The third division of present-day research provides us with the generalized, speculative article, which surveys and reflects upon what other authors have treated rather narrowly. Frequently the intuitive insights displayed in these articles run contrary to the case studies surveyed.

For example, Eugene Jennings, writing in the *Economic Education Newsletter*, amends the "no lay-offs" of the case study to read, *"Although there is no effective measure of technological displacement, any understatement of its magnitude may conceal the seriousness of the problem."*

One can find little fault with such a statement, but the conclusions of such an article would be given more credence if they were supported by whatever empirical evidence might be available.

Research of all three kinds is abundant, yet too specialized to provide a useful background of economic facts for use in developing government, company, or union policies. Much of importance lies between the boundaries of these areas.

Studies of a single operation should be extended to cover the entire industry; psychological studies can be broadened to include economic aspects; general articles strengthened and made factually valid by encompassing such statistical information as is available. We need a great amount of research free from the onus of special interest and directed at bringing the unknowns of automation under study and eventual control.

The questions come first

What lines will such research take? How much already is known about the automated society? How can we best direct our thinking to solve the problems of occupational shift, displacement, and upgrading in a fair and reasonable manner? So far, we have only a faint insight into the answers to these questions; indeed, we have only begun to understand the questions themselves.

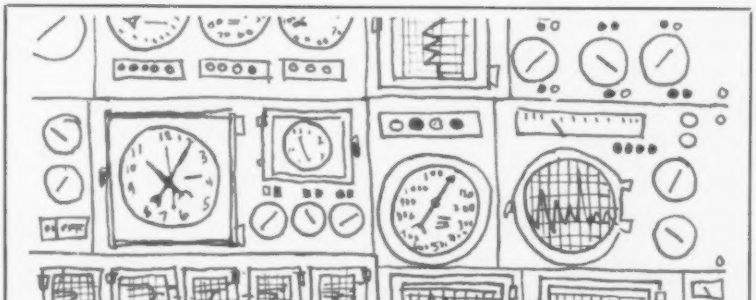
Much of what we have now has come from the labor unions which have had to face the problem squarely and formulate lines of remedial action. And particularly the automobile unions, since it was the auto industry which has had sufficient capital and a sufficiently high-volume uniform product to enable it to pioneer in automation development.

Ford's famous Cleveland Engine Plant No. 1, which opened in 1951, was hailed as revolutionary because of its integrated automatic machining and assembly line. A movie even was made illustrating its wonders. Today the Cleveland line is the oldest one at Ford — from first to last in seven years! So the automobile industry adds the factor of urgency: this is not a problem to be shelved as tomorrow's headache, but one which must be confronted immediately.

Let us consider a few of the problems brought about by automation, encountered not only in the automobile industry, but in plants and offices throughout industry.

Does automation = abundance?

Foremost is the question of the productivity increase of each production worker through the introduction of automatic machinery. Every auto-



"All you do is watch that indicator — when it turns red, punch that button and yell for the engineer."

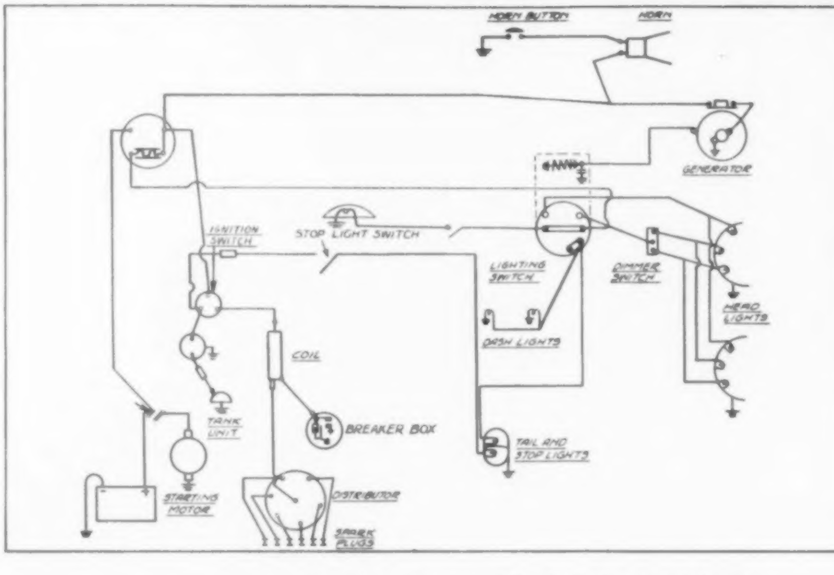
mated operation reported upon in technical journal or case study discloses a dramatic increase; yet, isolated instances give no indication of their effect on the economy as a whole.

Productivity increases of the past decade exceed those of previous decades. The 1958 *Economic Report of the President* showed an average annual increase in manhour output from 1947 to 1956 of 3.9%. Although productivity increases during the 1958 recession were slight, productivity again is increasing at a rate greater than in past decades.

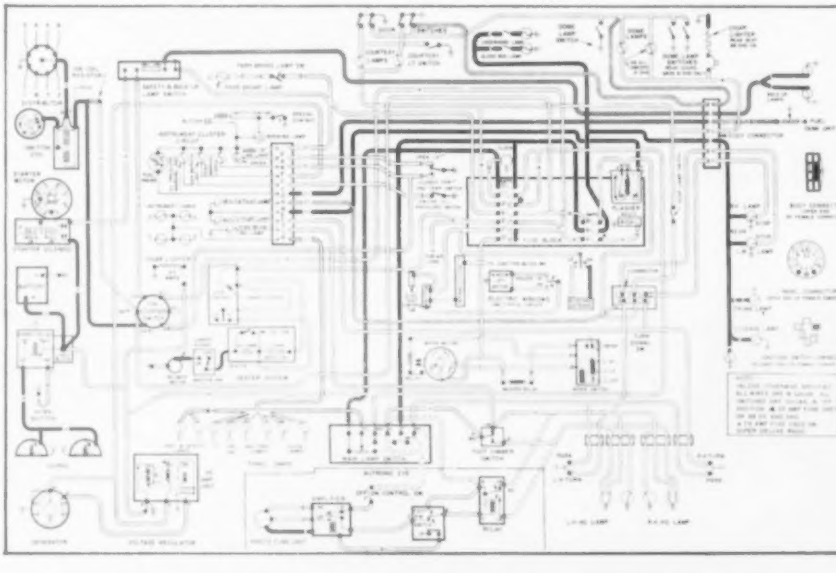
General articles do not often speculate upon the significance of this greater *rate* — but accept instead the traditional 2½% straight-line growth figure to be found in any economics primer. It is possible that an upward-sloping growth curve more nearly fits the facts. A careful study of actual increases would be invaluable in helping buttress general forecasts of the impact of automation on productivity.

A corollary to this problem often overlooked in automation literature is the relatively stable number of production workers employed in manufacturing. There were on the average approximately 12.8-million of them in 1947 and 12.6-million in July 1959 before the steel strike started. This same number of workers, however, now produces some 50% more. Forecasts show that the chances of employing more than the 1953 peak of 13.8-million production workers within the next few years are not great.

Therefore, future increases in manufacturing output will come from more productivity rather than from more employment. This central fact seldom is admitted frankly in general articles, but is approached guardedly and tentatively. Adequate research must be done on this development so that accurate predictions can be made concerning its impact on the economy as a whole. From it follow most of the problems of shifts, displacement, and upgrading which an automated nation cannot avoid.



WIRING DIAGRAMS *of automobiles built in 1935 (above) and in 1960 (below) illustrate growing complexity of technology. More intricate machines require about the same number of man-hours to build, but necessitate greater skills and cause occupational shifts.*



The great occupational shift

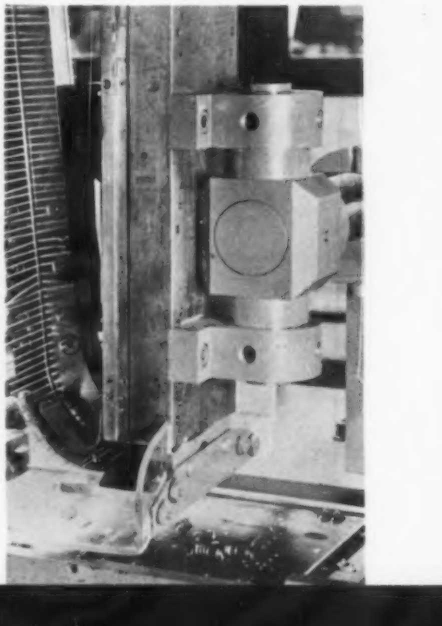
Providing for occupational shifts (production to non-production and unskilled to skilled), with all the related problems of retraining and relocation, presents the greatest immediate challenge to legislators and company and union officials.

Census trends show that *operatives*, formerly one of the fastest-growing occupational groups, will continue to grow in number, but probably at a rate slower than the labor force as a whole. Yet, we have no detailed information about this growth.

Since it is easier for the displaced *operative* to shift to a semi-skilled job outside manufacturing than to acquire the training needed to qualify for skilled trades or for a technical or professional job, increased research is needed to predict the scope of these shifts, causes of the slowdown, and to facilitate advanced planning.

Does this reduced growth rate, caused primarily by the replacement of operatives by machine, exist only in the manufacturing segment of our economy? Or is the application of automation sufficiently widespread to create similar changes outside of manufacturing? The answer to this question may force us to re-shape our educational thinking entirely.

A related problem is whether, as most automation articles imply, the



shift will be toward the skilled *craftsmen and foremen* classification as well as the *professional and technical*. It is not correct to assume (as many do) that rapid expansion in the latter category necessarily involves an increase in the former. The mix in most automated factories shows an increase in the ratio of skilled craftsmen to semi-skilled and unskilled production workers, but this is caused mainly by decreases of lesser-skilled workers — not by increases in the number of craftsmen.

Census figures show that the absolute number of craftsmen in manufacturing is increasing, but more slowly than employment in general. The percentage of skilled craftsmen in the total non-farm labor force actually decreased from 16% in 1948 to 15% in 1959.

Because this trend runs contrary to what most automation literature implies, it probably should be regarded with caution until further study is done. Misclassification or obsolete definitions may explain it. Or we might surmise that, even in this day of automation, industrial mechanization continues, replacing craftsmen with semi-skilled workers.

Whatever the explanation, the figures are clear, and are supported by Bureau of Labor Statistics projections for 1965, which show craftsmen as a slightly lower percentage of the total civilian labor force than in 1950. The contradiction clearly shows the paucity of information available. Once again, we simply do not know enough.

Office automation first: a fallacy

Another widely-accepted cliché in automation writing that warrants further investigation is the proposition that automation will have its greatest immediate effect on office occupations. The assumption is that the dramatic productivity increases associated with installation of electronic computers will have as great an effect, perhaps even greater, than that of transfer machines in the factory.

Apparently this is not true.

"Non-production workers have increased about 15 times as fast as production workers" in the decade ending in 1956, according to Ewan Clague, U.S. commissioner of labor statistics.

Although "non-production" includes more than the clerical occupations, one would not expect to find such changes if automation were having a greater effect in the office than in the factory. Further doubt is thrown on this proposition by the fact that in the past 20 years the *clerical* occupation group, according to Bureau of Labor Statistics figures, represents an increasing percentage of the labor force and will continue to do so.

This can be explained partially: while the end-product of manufacturing has not changed much because of automation, its introduction into the office has made possible statistical studies never before found feasible. Frequent sales and inventory studies — impossible tasks manually — have become invaluable aids to many offices.

Parkinson's Law may obtain here too, as each member of the increasing professional and technical group takes on additional clerical assistants to maintain status commensurate with his new and exotic job title.

Further research into various categories of jobs within the clerical field and some measure of the effect of automation upon each would help invaluably to resolve the problem. For the present, however, it would be somewhat wiser to avoid the theory that automation's greatest initial impact is on the office.

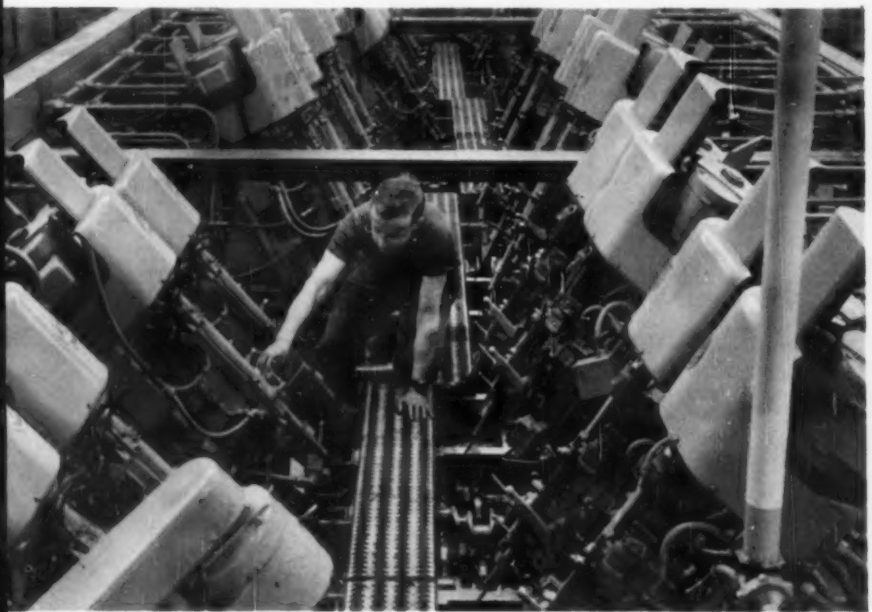
Jobs upgraded—not people

Another, more specific, proposition that is seldom examined critically is that the displaced production worker can be transferred easily to one of the expanding technical or professional occupations, thereby maintaining the level of employment.

"The hand trucker of today replaced by a conveyor belt might become tomorrow's electronic engineer," writes R. H. Sullivan, a Ford executive. He might indeed, but what is perhaps a more realistic view is taken by George P. Schultz and George B. Baldwin in their article *Automation, a New Dimension to Old Problems:*

"Automation will not upgrade people; it will only upgrade jobs. This is a simple but vital distinction, because it highlights the crucial transition problems. If John Romano, a 55 year-old grinder in Ford's crankshaft department, is thrown out of work by the introduction of an automated crankshaft machine, and George Pichelski's 20 year-old boy decides to go to a school for electronic technicians instead of going to work as a drill press operator (and does in fact land a technician's job two years later at Chrysler), it is stretching language and compressing reality to say that a semi-skilled operator has been upgraded into a highly skilled technician."

Problems of the semi-skilled worker are mounting as automation cuts down his chances of returning to his old job. Max M. Horton, director of the Michigan Employment Security commission, has released figures indicating that "hard-core" unemployment in Michigan has quadrupled itself in recent years because, as he said, *"It is well established that the auto plants,*



MASS PRODUCTION *was never like this in the days of Henry Ford. The 52-foot automated machine at Ford's Lima, O. plant (above) automatically drills the entire oil system in an auto crankshaft in one operation. Left, a man-less machine inserts resistors on a printed circuit board at Admiral Corp. in Chicago.*

with their increased productivity, will be able to make all the cars they want with fewer workers."

Such developments point up the urgent need for more intensive studies of displacement and re-employment in major labor markets where mass production formerly offered the bulk of employment opportunities to semi-skilled workers.

Steelland in distress

Within a few years the auto-producing areas of Michigan and the steel-producing areas of Pennsylvania could well become distressed areas with *chronic* unemployment in excess of 10%. At that time it would be necessary for labor, management, and government to provide for increased relief and relocation. Research *now* will equip us to deal more satisfactorily with this problem and also may uncover methods by which it may be prevented.

Displacement of the production worker, the final and perhaps greatest effect of increased automation, is both direct and indirect. Direct displacement occurs when a job is eliminated because automatic machinery is installed — the worker either being laid off permanently or transferred to another department where manpower needs are expanding. (Most case studies are confined to the more successful transfers.)

Indirect displacement is the elimination of a job when increased productivity associated with automation within one firm so exceeds the growth of the product market that rival or supplier firms are forced out of business.

Union and management efforts to alleviate unemployment arising from automation usually are confined to instances of direct displacement. The bargaining table already has seen many examples of agreements relating to direct displacement, such as the 1958 UAW-Chrysler contract which established a common area pool of laid-off workers, re-hired according to seniority, and the UAW-General Motors pact allowing workers to follow their jobs from one part of the country to another.

Displacement —during prosperity

These efforts, however, cannot lessen hardships suffered by those thrown out of work because of indirect displacement, even in prosperous times. And here we must look to legislative remedies, since there is no longer a solvent company with which unions can negotiate.

For example, the Murray Body plant in Detroit, a former major Ford supplier, closed its doors in 1954 because Ford's automation had so increased its productivity that it no longer needed Murray stampings — formerly one-third the total. Although Murray Body failed at the beginning of the 1955 model-year, a record year for the industry, a survey conducted one year later by Harold L. Sheppard, a Detroit-area university professor, established that only 71% of the Murray men had found jobs by that time, and that 50% had exhausted their compensation before being re-hired.

It becomes increasingly apparent from instances such as this that compensation laws in most states need to be re-written in the light of increased automation. Not only are they inadequate in benefit and duration, they usually do not take into account new problems to be encountered in an automated society.

The challenge of automation

Our economy is being automated at an accelerating pace. Sales of automatic controlling instruments, automatic transfer and feedback machines, and large and small computers have increased rapidly over the past few years. Numerical control has moved from the MIT laboratory to the factory floor.

Yet our study of the economic implications of automation has not kept pace with its technological development. The literature is spotty, compartmentalized, and of little use in guiding legislative, company, or union policies concerning the central factors of displacement, shifts, re-training, and compensation for the unemployed. Many of the estimates of the past few years are now as obsolete as Ford's first automated engine line in the Cleveland plant.

If social science research is to be useful in assessing the effects of automation, we must shorten both the lead time from field research to finished report and the lag time between technological change and measurement of its economic impact. Academic studies must be broadened to include economic as well as sociological and psychological factors arising from automation.

Automation, properly introduced, can be a blessing to labor as well as management. At present, it is a challenge. To meet that challenge we need unbiased research, free from vested interests and politicking, and encompassing all the facts we can command. ■

For the technical man who wants a key to the future **... (see page 66)**

SILICONE NEWS from Dow Corning

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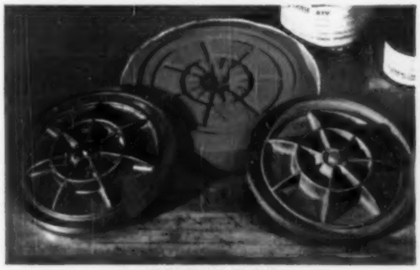

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broom at the top – EXECUTIVE

by **Dr. Chester L. Brisley,**

DURING THE PAST DECADE industry has become increasingly self-conscious. Analysis, interview, study, survey, and measurement have added an entirely new dimension to sales, finance, production, and engineering. Everyone from sweeper to statistician has felt the prod of the scientist's instrument; yet, the efficiency of the executive still has been little explored. No job analysis has been done for the boss, no instructions are issued when his name is painted on the door of a private office. The working day on the production line is prescribed down to the finest detail; how the executive spends his time is left to his own judgment.

Since the executive has no rules to guide his activities, personal factors often strongly influence him. Instead of a deliberate, pre-planned day, his efforts are subject to constant interruption and governed by chance occurrences; he fails to assign and carry out priorities; too often he does not do first things first. He may favor that branch of the business from which he was promoted, or pay more attention to that aspect of the company with the most aggressive and vociferous spokesman.

Because of the impact on executive behavior of such seemingly irrelevant factors, there is a growing recognition of the need for executives to allow — even to insist — that job measurement and work simplification be applied to themselves.

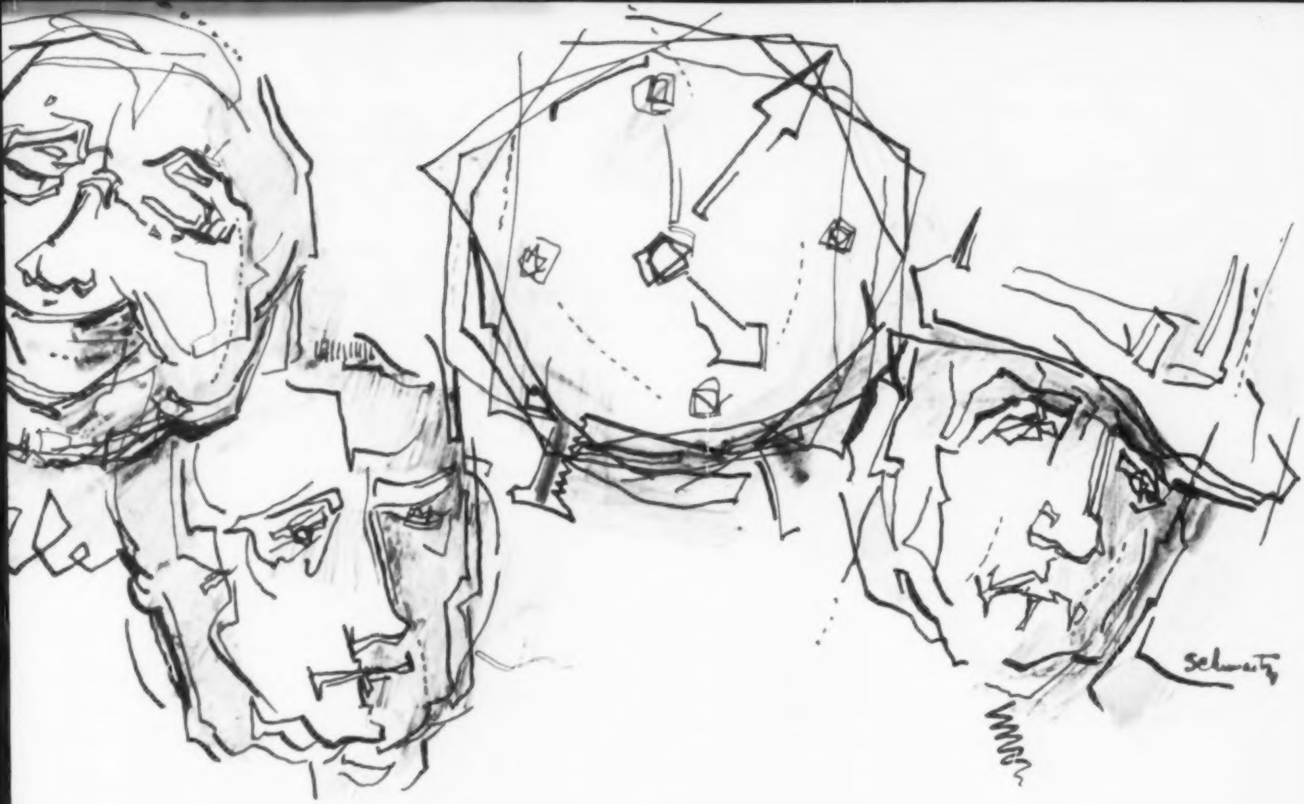
But, before efficiency can be increased, it is necessary to evaluate how and what part of an executive's job can be improved. Unfortunately, the personal laissez-faire way in which executives conduct their jobs does not permit easy measurement.

Business or busyness?

Successful executives, even those who are inefficient, show high drive and achievement desire. An executive conceives of himself as a hard-working person who must accomplish to be happy. The Bureau of the Census reports that managers and proprietors average a 53-hour work week; a 70-hour week is not unusual in the executive suite. The executive volunteers his added efforts, while most subordinates have been saved from the long work week by labor-saving machinery and industrial planning.

Although the executive works long hours, the question may be asked: Is he actually efficient, or is he too busy to be efficient? He has risen in the organization because of his abilities, but has his productivity kept pace with efficiencies in the factory?

An analysis of executive on-the-job behavior can be of great help in increasing efficiency, but will not provide a neat formula by which he can reorganize his efforts simply and directly. Even on the lower echelons,



INEFFICIENCY

staff assistant to the director of production, Chance Vought Aircraft Inc.

rules of thumb defeat their own purpose. The best that studies can achieve is a perspective which will allow an executive to consider his own activities, find his inefficiencies, and thus make better use of his time and creative efforts.

Analysis enables the executive to judge if his daily activities really are directed with the fullest possible efficiency toward the realization of his goals. Examination of the old timetable generally leads to an entirely new one for the future, incorporating the answers to questions like:

Why did I do it? Was I the right man for the job? Did I do it at the right moment? Couldn't I have eliminated that phone call? Should I have projected what was likely to happen at the meeting? Why must I meet with Joe once a week instead of twice a day?

Of the few studies on executive inefficiency already completed, these

The inefficient executive . . .

. . . never finds himself alone.

. . . allows chance and interruption to govern his day.

. . . works too "hard."

. . . lingers on long distance while visitors wait.

. . . cannot delegate responsibility.

. . . over-consults, over-directs, over-repeats.

. . . does not have time to think or plan.

. . . continues doing the job from which he was promoted.

. . . has not defined his job.

. . . lets personalities influence decisions.

. . . is too busy to read this article.

common patterns of behavior have been observed:

- Personal productivity often is curtailed, ironically, because an executive works too hard. Enthusiasm yields excessive work habits, which yield an inability to relax from the tension.
- A large part of his work is repetitive. He has repeated conferences and conversations with the same persons, often about the same things.
- His most essential job — thinking and planning — is done in fragmented intervals too short to allow him to carry his thoughts to optimum conclusions.
- Many of the tasks he performs in a day are not executive functions. An executive develops a pattern, determined in part by his organization and in part by activities that give him satisfaction. Thus, an executive who prefers speech-making and travel finds subordinates to do his office work. Certain combinations of work patterns result in a balance; others create difficulties.

Work sampling vs. time study

Several methods have been set forth to measure the effectiveness of executive behavior. Often time study during the course of several weeks is proposed, but this entails either constant observation with a stopwatch or self-evaluation, both of which actually may inhibit the executive's efforts and distort the picture. Time study is more technical and thus more expensive, but does not achieve the accuracy of simpler methods.

The technique favored by the American Management Association is the setting up of standards and production goals among superiors and subordinates. Performance is charted and new agreements made periodically in the light of the attainments. Not actually a method for work measurement since it involves arbitrary goals, a performance standards program usually is used to correct deficiencies already determined.

Third, and perhaps best, of these measurement devices is work-sampling. It in no way affects the behavior of the subject, since it involves random, instantaneous observations rather than close scrutiny. It is simpler and even more accurate than time study.

Probability and productivity

Work-sampling is based on the laws of probability, specifically normal and binomial distribution: a smaller number of chance occurrences tends to follow the same distribution pattern that a larger number produces.

Although work sampling as a technique has been in use in industry for some 30 years, it seldom has been applied at the executive level. Developed in 1927 by L. H. C. Tippett, a noted English statistician, it was used primarily to study the lower echelons of business organization. As late as 1950, when Sune Carlson of the Stockholm School of Economics made a study of a number of Swedish business directors, he did not use it.

The Swedish study pioneered the application of time logging to top management levels. No attempt was made to compute the average day of these men, and Carlson offers these figures as "hypothetical," yet they constitute the first significant study of the use of executive time, and provide the basis for subsequent studies.

One significant fact noted by Carlson and borne out by later studies is that the executive actually spends very little time alone without interruption and work which requires real concentration often must be saved for after office hours.

Recently, a section chief at Chance Vought Aircraft agreed to undergo a work sampling study. His activities

SWEDISH DIRECTORS STUDY

	time spent
OUTSIDE THE FIRM	44%
Conferences and visits	33%
At home	8
Traveling	3
INSIDE THE FIRM	56%
Visits to factory	9%
Consultation	6
Visiting subordinates	1
Lunch	5
Conferences and visits	25
Working alone	10

The executive worked alone only one hour a day, in intervals of only five or 10 minutes. Time shown "at home" represents about one and a half hours a day. The main part of work at home, according to Carlson, consisted of reading business journals and various memoranda and reviewing statistical reports. Some executives did all their dictation and writing which needed real concentration at home. One used his home for important conferences with associates.

SECTION CHIEF STUDY

	HOURS A DAY	PER CENT
Administrative & supervisory	1.52	19%
Staff responsibilities	1.28	16
Reviewing mail & correspondence	1.20	15
Estimates, budgets, and costs	1.12	14
Liaison with other sections	.80	10
Dictation & office maintenance	.64	8
Progress review meeting	.56	7
Scheduled status review	.32	4
Liaison with other departments	.32	4
Phone calls	.24	3
	8.00	100%

This study comprised 717 random observations over a period of 22 working days. As a part of the study, the frequency of interruptions by telephone and visitors was charted, compared to time the section chief was able to work alone. About 240 interruptions occurred each week, — one every 10 minutes!

LINE AND STAFF STUDY

	MANAGEMENT hrs/month	MANAGEMENT per cent	OPERATIONS hrs/month	OPERATIONS per cent
Consultation	14.2	10.5%	4.8	3.6%
Deciding upon a course of action	12.6	9.4	8.5	6.3
Discussion	8.3	6.2	5.3	4.0
Interviewing visitors	4.0	3.0	4.7	3.5
Telephone	11.8	8.8	11.1	8.2
Dictating	5.0	3.7	2.6	1.9
Meetings	12.7	9.4	13.5	10.0
Luncheon discussions	19.4	14.3	15.0	11.0
Visiting other offices	20.0	14.7	48.9	36.1
TOTAL ORAL COMMUNICATION	108.0	80.0%	114.4	84.6%
TOTAL READING	17.7	13.2%	12.4	9.2%
TOTAL WRITING	5.6	4.1%	5.0	3.8%
MISCELLANEOUS (clerical, thinking)	3.7	2.7%	3.2	2.4%
	135	100 %	135	100 %

Calculations determined that executives and operations managers worked an average or 173 hours per month including the lunch period. As determined by work sampling, executives were out of the plant about 38 hours a month; thus the figure used above is 135 hours per month for time spent in the office. The percentages were adjusted to reflect time-in-office only. The study was conducted only from 8 a.m. to 4:45 p.m.

were broken down into 10 categories and he was observed over a period of 22 working days. During all this time the longest period the subject spent alone was less than half an hour!

Comparing line and staff

A more comprehensive and detailed study of executive behavior was made in a Detroit manufacturing firm. Since the study's purpose was to compare line and staff executives in the top echelons, executive functions were divided on two levels, top *management* and *operations* management.

Management personnel included those reporting to the general manager: controller and assistant controller, director of industrial and public relations, director of purchases, and plant manager.

Those classified as *operations* personnel reported to the director of operations and comprised managers of quality control, product development, engineering and industrial engineering, production planning, and the technical manager.

Each of the 11 executives was observed 750 times, at random, a total of 8,250 separate samplings. Executive functions were broken down into detailed but readily-recognizable actions which later could be combined. Activities were defined rigidly so that it was not necessary to query the subject, distracting him, and possibly distorting the final statistics. After the observations, depth interviews were held with each subject to determine attitudes toward certain policies and practices. The following appraisal was made of the efficiency of the group as a whole (see study chart on page 60):

▪ *Consultation (with peers or superiors).* Management consulted three times as much as operations personnel during the period of the study.

The reason for the difference was difficult to understand at first, but we found that management offices were centralized, while operations was dispersed, closer to the areas of responsibility. Since office location has a bearing on the frequency of visits of one executive to another's office, the need for a better plant layout became evident, and was effected at a later date. (While the reason for over-consultation here is obvious, the situation probably is typical of management as opposed to operations offices throughout industry.)

From answers to depth interview questions, executives do not feel that interruptions interfere with efficiency to a large degree, and apparently preplanned conversations much more than would be supposed.

▪ *Deciding upon a course of action (with subordinates).* The executives studied, particularly those in the management group, were concerned over the amount of time spent with their immediate subordinates. They felt this time to be excessive, and, partially as a result of the study, a group appraisal and performance program was initiated to create standards for measuring subordinates and thus increase efficiency.

Establishing goals for each subordinate within overall objectives of the company seems to eliminate needless direct communication, and the process of deciding upon a course of action is refined and improved.

▪ *Discussion and interviews (with lower-level management and outside representatives).* Time spent in such discussion on both levels was nearly equal, and constituted less than 10% of the total. While these conversations varied greatly, each executive felt he could control their length and direction.

The investigators feel that more prior thought and planning is needed on all levels of direct communication. A certain amount of redundancy is necessary, even desirable, but the study showed that in most cases a fifth or even a tenth as much would suffice.

▪ *Telephoning.* While telephone calls took about as much time on both levels, management personnel more often were guilty of telephone-talking while others were kept waiting. Few felt the telephone actually interfered with their work, yet they hampered the efficiency of others by keeping them waiting.

(The "excitement" of the telephone seems not to have worn off, even with executives. Long-distance calls especially are given priority over subordinates and other visitors waiting in the reception room. The practice is widespread among executives, even though they realize that postponing a call inconveniences the caller much less than the man in the outer office, who has nothing to do during the interval except build up tension.)

Most executives in the study made it a policy to answer the telephone themselves whenever possible so that callers would not feel they were acting aloof. This practice has merit from a public relations standpoint, but scores low on efficiency because calls are not screened or directed to the proper person.

▪ *Dictation.* The study did not confirm the widespread belief that executives spend a lot of time dictating to a machine or secretary. Much of the secretary's time is taken up with errands, filing, and answering the telephone. Few executives pre-planned dictation, preferring to call in their secretaries immediately after reading a letter or completing a telephone call.

Dictating machines, many of which were bought after the study proved their usefulness, were used extensively in giving directions to the secretary about planning trips or other routine matters which she could pursue at her convenience.

▪ *Meetings.* We found that operations personnel meet more often but spend less time at each meeting, so the total time is about the same on both levels. Executives in the study

Twenty-five years of studying executives—both efficient and inefficient—have equipped Dr. Chester L. Brisley to wield a "broom at the top." He entered industrial engineering with a degree from the GM Institute while employed at Packard Electric, and received his doctorate in 1957 from Wayne State University. At Wolverine Tube in Detroit he pioneered a work-sampling program which has served as the model for many other industrial firms. Out of this experience grew the chapter on work simplification published in the 1956 edition of the Industrial Engineering Handbook. He joined Chance Vought in 1958 as a staff assistant in production, and since has been engaged in formulating basic programs in work simplification and operations research.

felt they actually saved time by attending these meetings, conducted by committees with much of the material in the participants' hands well before they were called.

Eight out of the 11 felt there was a danger of overcommunication in having meetings too frequently. There is some evidence in the minutes of these meetings of duplication and even conflicting information at various levels.

■ *Luncheon discussions.* Because they are informal, luncheon meetings were found to stimulate a relaxed atmosphere, considered vital to effective oral communication. Discomfort was shown in several cases where the executive's work sample showed he had exceeded the designated lunch hour.

■ *Reading and writing.* Little reading of periodicals, journals, or newspapers seems to take place in the office at either executive level. Most journals merely are noted as they cross the desk, with an occasional magazine dropped in the briefcase for home reading. The practice seems to bear out the findings of previous studies, especially Carlson's, which determined that the average working time at home was one and a half hours — consumed by reading journals and memoranda and reviewing statistical reports.

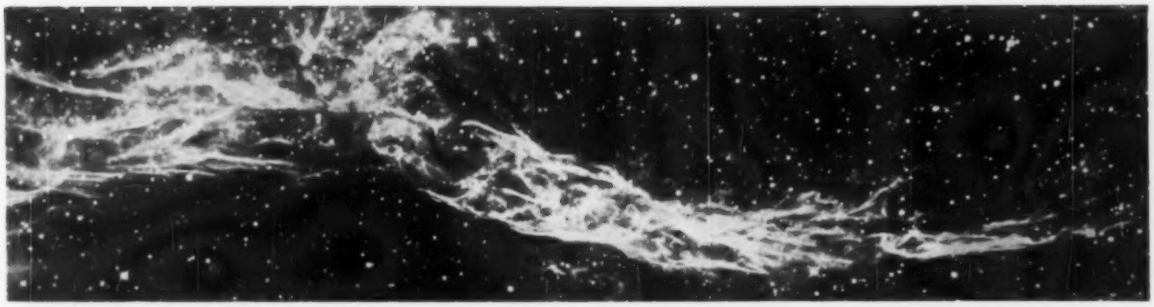
Even though executives spend more time writing than operations managers, both groups, surprisingly, spend comparatively little time at this activity.

Executives under study were considered to be thinking or planning when inactive. The degree to which this contributes to managerial ability is uncertain, but executives probably should spend a lot more time at their prime jobs — thinking and planning.

Sampling = work simplification

Although the value of any behavior research is limited in establishing fundamental principles of human activity, the study pointed out that executive inefficiencies do exist and can be corrected by using proper tools. The facts uncovered proved valuable in increasing efficiency in a specific situation and a specific company, because for the first time the executives studied were able to take a long, objective look at what they were doing.

The great value of work-sampling lies in its ability to present facts about the individual to himself so that he can make a personal effort to correct his inefficiencies and stop being "just busy." Effectiveness can not be measured in terms of minutes and hours, of course, but some standards must be set up if it is to be increased at all. ■



I•R NEW AIRCRAFT DEVICES

1. flying belts

2. smoother landings

3. simplified radio

4. accurate fuel gaging

BUCK ROGERS' famous flying belt finally has emerged from the research lab, in preliminary form. While you can't actually fly with the belt, you can jump over small buildings and run faster up mountains. Thus the belt has application in the military for rapid dispersing and re-grouping of ground forces, formerly impossible with truck and jeep transportation.

Several types of flying belts have been developed by the Reaction Motors Division of Thiokol Chemical Corp. Trademarked "flyBelt" and "jumpBelt," the devices are part of an industry-wide attempt to develop one-man vertical takeoff vehicles. (See I•R *The Flying Machine: a New Era, part 1*, Jan., 1959, and *Another Automobile Revolution*, Nov-Dec, 1959.)

The one-man helicopters, flying jeeps, levicars, etc. are fairly large and heavy compared to a man, and are more expensive and difficult to maintain than an automobile. While these vehicles rely on air-blower or rotor propulsion, the flying belt's shove is merely a solid-propellant rocket.

Infantry in three dimensions

Advantages for military use are many. The infantryman normally comes to grips with the enemy as a self-powered individual advancing at three and a half miles per hour or, in runs of under 100 yards, at 14 mph. The jet thrust of a jumpbelt, however, could permit a soldier to run 300 yds at 30 mph, jump across 50-ft streams and ditches, or leap 20 ft into a building or onto a wall.

Used in reverse, as a brake, the jumpbelt would allow high-speed paratroop drops. The method minimizes paratrooper drop time and cuts down dispersion due to wind drift.

One of the basic requirements for a true *flying* belt is that it should be capable of being carried by the operator when not in use. That is, the weight should not exceed 100 lbs with propellants. It should lift a useful load of about 240 lbs, such as a large soldier with combat gear, and fly him at least 10 miles at 60 mph on its own propellant supply. It should be capable of vertical take off and landing. In addition it should be simple to use, easily maintained by the operator, and pose no difficult field logistic supply problems.

FLYBELT in position for takeoff is strapped on like a pack; still under development, perfected belt would permit flying 10 miles at 60 mph.

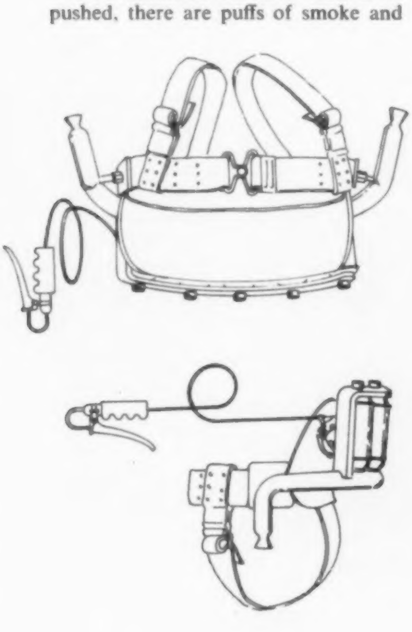
Flybelt missions

Thiokol envisions an attack carrier lying a few miles off shore supporting a shore invasion. On deck the companies of assault troops are assembled, but nowhere are there any landing craft or helicopters to transport the troops.

A company of troops steps forward along one side of the deck, each man carring his rifle at his side, a pack on his back with assemblages hanging down on each side like folded wings. In unison a button is pressed, the folded assemblies rise smoothly until each man now has a set of "wings" with a nozzle at each tip.

On command another button is pushed, there are puffs of smoke and flame, a thunderous roar, and then slowly at first the men rise and swiftly form and fly towards land. Within minutes the deck is cleared and another airborne assault is underway.

The dream includes civilian operations too: helping life guards and firemen in rescue operations. Industrially, the flying belt could provide a safety measure on bridges, dams, and other construction operations.



Today's belts: $300

But the present "flying belts" developed by Reaction Motors fall short of this goal. They don't fly; they jump. According to project engineer Alexander H. Bohr, the jumpbelt merely supplements the operator's natural body motion with its thrust force. The jumper triggers a simple, hand-held percussion mechanism that sets off the propellant charges without interfering with his normal body movements.

When the propellants are burned, high-temperature high-pressure gas is produced and discharged from five nozzles. The energy is supplied from solid propellants containing both oxidizer and fuel; thus the belt has application in air, space, or underwater.

The belt is designed so that the thrust forces lie in a plane passing through the operator's center of gravity. In this way, thrust is applied with no tendency for overturning.

The first available jumpbelts will cost about $300 in limited production quantities. Three basic models are being produced: belts weighing 25 lbs, 16½ lbs, and 10½ lbs will produce a total impulse of 2,400, 1,200, or 1,200 lb-sec respectively. (A 2,400-lb-sec model could produce 120-lbs thrust for 20 sec, which would permit an average man to dash 300 yards at 30 mph.)

2. Smoother landings

Meanwhile, some more orthodox research is making conventional flying easier. A new landing gear to facilitate rough-field takeoffs and landings has been developed by Battelle Memorial Institute for Fairchild Engine & Airplane Corp. The gear employs a low-pressure tire with a valve system that automatically bleeds air from the tire on landing. The bled air dissipates impact energy, thereby preventing the aircraft from bouncing.

The tire is deflated through a sleeve valve controlled by the weight of the aircraft bearing down on the landing gear. The valve automatically closes when a given minimum tire pressure is reached. Pressures have been reduced rapidly from 17 to two pounds per square inch upon landing.

With the weight of the aircraft distributed over a greater surface, under

low tire pressure, the tire will not sink as deeply into soft earth or sand fields and rolls easily over rocks or debris instead of bouncing.

The greatest obstacle encountered in the design was the fact that low-pressure tires must be considerably larger than a conventional tire to bear a comparable load. Thus the Battelle engineers worked out a high-tensile-strength tire that can be fully deflated upon take-off before being retracted into the airplane. The thin, pliable tire is folded into a helical bellows, and its volume reduced to less than one-fifth inflated size. Before landing, the tire is inflated, again automatically.

3. Simplified radio controls

An experimental cockpit panel devised by Bendix Radio Division integrates the switching functions for all of a plane's radio equipment, enabling a pilot to switch his radio equipment without looking at the control panel.

A single indicator is used for mission and traffic control functions. The desired function and digit, either a channel number or a frequency, are selected from the keyboard, which contains all in-flight controls. This information is stored in the switching unit until an actuate key is pressed.

The big advantage is simplicity. Normally used in-flight controls are reduced by half and take up only half as much space.

4. More accurate fuel gage

The new "BLIP" fuel gage designed by Sierra-Schroeder Controls Division for ground use is highly accurate and fast, eliminating any possibility of fuel loss or leakage.

The gage consists of a housing bolted to the inside of the fuel tank and a slip tube which passes through the housing into the tank. When the gage is closed, the base of the slip tube is flush with the bottom surface of the tank. To take a reading, the base of the slip tube is twisted and unlocked, then pulled down slowly.

When the end of the tube is above the level of the fluid, incident light causes the inside of the tube to light up. However, as soon as the end of the tube is immersed in the fluid, the light is absorbed. When the light, as viewed from the base of the tube, goes out, a reading is taken on the scale along the tube's outside surface. The reading indicates the exact level of the fuel.

The slip tube assembly can be withdrawn from the tank without leakage because a flapper connected to the gage housing closes over the opening as the end of the slip tube passes through. ■

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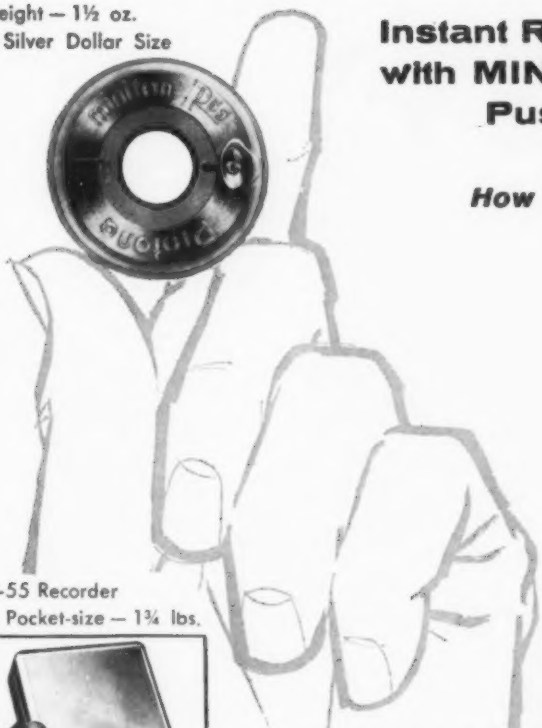

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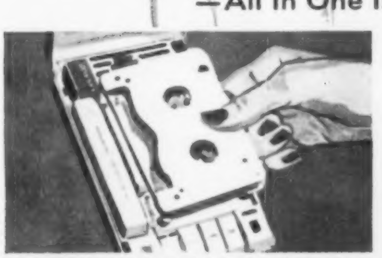

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Back in 1956 this General Electric organization outgrew its quarters in Schenectady, N. Y. and moved to Philadelphia. Since then its research and development staff has increased 5-fold. A new move is fast becoming imperative and will be met by the $14,000,000 Space Research Center now under construction on a 132 acres site near Valley Forge Park. This construction will feature unique facilities, to be utilized in a long-term program, to expand the activities in the realm of space research and the development of space vehicles and systems—areas in which MSVD has already contributed so many notable advances:

- the FIRST re-entry at ICBM range with both heatsink and ablation methods
- the FIRST recovery of payload from space
- the FIRST movies of earth from space
- the FIRST flight demonstration of effective space vehicle stabilization control and navigation (control systems of interplanetary capacity)
- the FIRST measurements in space of earth's magnetic field and infrared radiation
- the FIRST meteorological information from space
- the FIRST organic plastic ablation material for nose cone re-entry protection capable of withstanding temperatures from 5,000 to 13,000°F

Currently a broad diversity of programs are under way at MSVD, offering assignments of exceptional interest to engineers and scientists qualified to work with a research-oriented organization. Your inquiries are invited regarding the following areas: SYSTEMS ENGINEERING • AERODYNAMICS • THERMODYNAMICS • GUIDANCE & CONTROL • INSTRUMENTATION & COMMUNICATION • PLASMA PHYSICS • GAS DYNAMICS • AEROMEDICAL DESIGN ENGINEERING • ANTENNA & MICROWAVE DESIGN • SPACE MECHANICS • STRUCTURAL DESIGN • ENERGY CONVERSION • HUMAN FACTORS • ADVANCED POWER SYSTEMS • RELIABILITY ENGINEERING • PRODUCIBILITY ENGINEERING • ARMING AND FUZING SYSTEMS • APPLIED MATHEMATICS & COMPUTER PROGRAMMING

Write in confidence to: Mr. Thomas H. Sebring, Div. 201MB

Missile & Space Vehicle Department

GENERAL ELECTRIC

3198 Chestnut St., Philadelphia 4, Pa.

DIVERSITY OF ADVANCED PROGRAMS NOW UNDER WAY AT MSVD INCLUDE:

- Follow-on contracts for 2nd generation nose cones
- NERV (Nuclear Emulsion Recovery Vehicles) for NASA to study the Lower Van Allen radiation belts at altitudes from 200 to 1800 miles
- STEER—a communications satellite to provide global military radio communications.
- Satellite Aero-Medical Recovery Vehicle (SARV) for Discoverer
- Study programs in the area of accessory space power for a variety of missions, including chemical, nuclear and solar energy sources, electrolytic fuel cells and thermoelectric and thermionic converters
- Studies for three of the nation's space agencies to develop more accurate "space maps" than have hitherto existed to guide rockets and manned flights to the moon and planets.

A well qualified scientist or engineer is likely to find advanced work going on at MSVD on almost any field of space research of special interest to him.

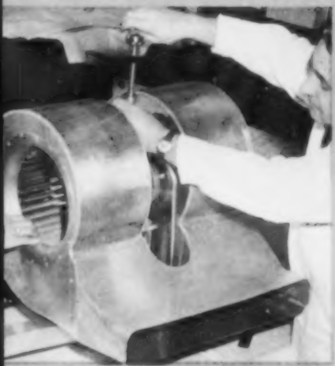
A campus-like setting is planned for the new Space Research Center which General Electric's Missile and Space Vehicle Department is building close to historic Valley Forge Park. Situated at the junction of the Schuylkill Expressway and Pennsylvania Turnpike, the Center will be easily reached by engineers and scientists living in the Philadelphia area and in southern New Jersey.

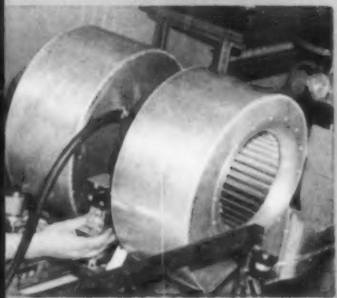
MILITARY R&D

Washington, D.C.
February, 1960

Dear Sir:

Air Force and other Defense officials are interested in compressed-air levitation as the ideal way to handle air cargo or operate an Ordnance or Quartermaster depot. Ford's Aeronutronic Systems has a Defense contract to evaluate various types of levi-systems that already have been demonstrated successfully—including Ford's own levicar.





◄Heavy-duty levitation employs a strong jet of air to lift the subject a few thousandths of an inch and keep it there. Thus, instead of sliding heavy equipment or crates on wheels or on a film of grease, one man will be able to slide several tons on air.

Ford employes already have moved heavy machinery this way. They place steel levipads under machinery, run in a pipe from a compressed air tank to a hole in the pad, and turn on the valve.

(A number of years ago, NACA (now NASA) engineers built a huge blow-down wind tunnel at Wallops Island, Va. The almost inexhaustible supply of high-pressure air was used to float large metal plates. What started as an amusing pasttime led to designs for flying platforms now produced.)

Gen. von Kann believes the Army may have more planes than the Air Force by 1970. Reason is not only the increasing Air Force and Navy emphasis on missiles at the expense of airplanes, but also the Army's own changing concepts. "We cannot double the Army's manpower," von Kann says, "but we can more than double its potential through air mobility."

Industrial researchers must get used to the idea of having the production man looking over their shoulders, according to the Army's chief of R&D, Gen. Arthur G. Trudeau, who authored this column last issue.

The best time to simplify is during development of materiel—in other words to inject maintenance thinking into design. It's difficult to write this concept into R&D contracts, but the Army's trying. These are the objectives:

Reduce frequency in cyclic and corrective maintenance; improve accessibility for adjustment

and repair; make possible the use of standard parts, tools, and test equipment; increase use of throw-away components; and improve reliability.

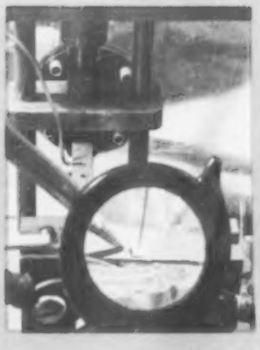
Diamond Ordnance Fuze Laboratories here has miniaturized two devices that will solve a lot of Army and industrial problems:

◄1. An electric light so small it can pass through the eye of a large needle. Uses are in dials, endoscopes, and medical probes for examining cavities, and in optical systems requiring a near point light source.

◄2. A radio transmitter the size of a pencil eraser. It will be used in ballistic studies to determine in-flight temperature of an artillery shell and relay the data to the ground.

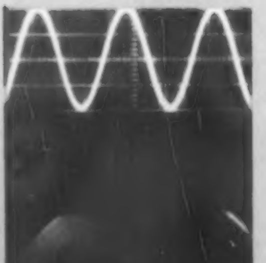
One novel application for the tiny, transistorized, battery-powered device is to transmit an electrocardiograph from a space-bound animal to earth. Aeromedics at Brooks Air Force Base, Tex. plan to strap the device to a mouse's back, where he cannot chew it. Muscular electro potential would actuate the transmitter to tell scientists whether the animal is moving, crouching, or imobile.

Electrocardio-electromuscular transmitters also are being developed for use on men, to telemeter an astronaut's physical condition. Industry can use them to measure workers' movements on the job; they would be almost unaware of the tiny transmitter taped to chest or back.



◄Phosphorous and gallium, two elements that melt in the summer sun, have been combined by Army researchers into gallium phosphide, capable of withstanding temperatures up to 1500 F.

Used in a diode, gallium phosphide proved seven times more heat resistant than either germanium or silicon, and may help solve temperature problems encountered by electronic parts in missile nose cones.



◄Pattern at left, top, shows gallium-phosphide diode's ac cycles; bottom view shows how tube flattens the lower half, changing pulses to dc.

To meet the needs of military high-temperature research, the National Bureau of Standards is developing techniques and devices to measure temperatures up to 20,000 K. Major interest is on electric arc techniques. Part of the program

is to find simple, reliable methods for producing the temperatures.

The NBS free-radical crash program now has tapered to a routine effort. But several devices have emerged:

> Most important is the series of new glass Dewars designed to make handling of liquid helium and other cryogenics easier. The Bureau also developed a system for getting liquid hydrogen from suppliers, trained personnel in latest handling techniques, and make it so easy to ship the stuff that it's now readily available to laboratories anywhere.

The program showed that free radicals will not be a fuel source for a long time. Emphasis now has switched from the radical as a fuel to the mechanism of radical reaction as a research tool.

In the meantime, the services will continue to rely on conventional liquid and solid propellants, with investigations of improvements and possible "exotic" additives.

Companies with interests in Washington should seek government R&D contracts, acquire a need-to-know status, and get on the list of the Solid Propellant Information Agency, operated from the Applied Physics Laboratory, The Johns Hopkins University, Silver Spring, Md.

SPIA's job is to eliminate duplication in programs by keeping the responsible government agencies informed of everything going on in solid propellants. It has information and publications available to contractors.

> Address requests to one of these offices: Commander, Air Force Flight Test Center, Edwards Air Force Base, Calif., Attn: FTRDS.
>
> Department of the Army, Office, Chief of Ordnance, Washington 25, D.C., Attn: ORDTB.
>
> Department of the Navy, Bureau of Ordnance, Washington 25, D.C., Attn: ReS6.

The Army is making information about the current status of more than 2,300 research projects available through its Annual Research Task Summary. A nine-volume work, six are available for public use. The ARTS covers work in 10 fields at 59 installations. Write: Office of Technical Services, U.S. Dept. of Commerce, Washington 25, D.C.

—The I•R Washington staff

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Wide range of applications: the RPC-4000 has been designed for engineering, scientific, business data processing and management control functions. Such jobs as product and process design, statistical analysis, research, inventory control, payroll and sales analysis are all well within its capabilities.

Easy to use: the RPC-4000 is simple to program and operate. Royal McBee compiling and translating routines allow even non-technical personnel to obtain maximum results. Versatile command structure gives programming speed and flexibility.

Available at low cost: high capacity, flexibility and ease of operation make the RPC-4000 the outstanding computer value on the market today.

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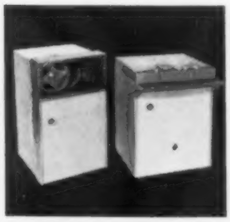
Heart of the RPC-4000 system is a new transistorized computer with advanced design concepts that provide substantial computing speed and capacity in a low-cost unit. Magnetic memory drum stores *8008 words.* Operating speeds are as high as 230,000/minute.

Standard input-output is a tape typewriter system which includes a Royal electric encoding-decoding typewriter complete with desk and chair, plus a tape punch-read console. Read speed is 60 characters/sec., punch speed 30 characters/sec. Typewriter, punch and reader may be interconnected in any combination for both on-line and off-line operations.



A new 500 character/sec. photoelectric tape reader and a 300 character/sec. punch are available as optional input-output equipment. A magnetic tape unit and a line printer will be available soon. As many as 17 input-output devices (60 with minor modification) may be connected on-line to the basic system. All peripheral equipment is under automatic program control of the computer.

Royal Precision Corporation

Royal Precision is jointly owned by the Royal McBee and General Precision Equipment Corporations. RPC-4000 sales and service are available coast-to-coast, in Canada and abroad through Royal McBee Data Processing Offices. For full, detailed specifications on the new, transistorized RPC-4000, write

ROYAL McBEE data processing division, Port Chester, N.Y.

Grace & Co.'s Headstart

In today's highly competitive industrial world no corporate structure that amounts to anything can look itself or the business analyst in the eye and admit it does not do research.

If you listen to any major investment advisory service in New York, Boston, or Chicago you are bound to hear constantly repeated comments on the value of corporations' research organizations and their programs. Most major investment services make periodic trips around the countryside studying corporations. When it comes to looking at companies in the chemical industry, the key questions seem to be: *Just how is the corporation's research program organized? How is it run, and who runs it? How much is the corporation spending? What is it getting in return for every dollar budgeted for R&D?*

Investors are just as sophisticated as the research programs they evaluate. Most large investors are not as interested in how well present products are doing compared to how well these products will do tomorrow. Worries over obsolescence and competition on present products are dispelled by sound corporate research programs.

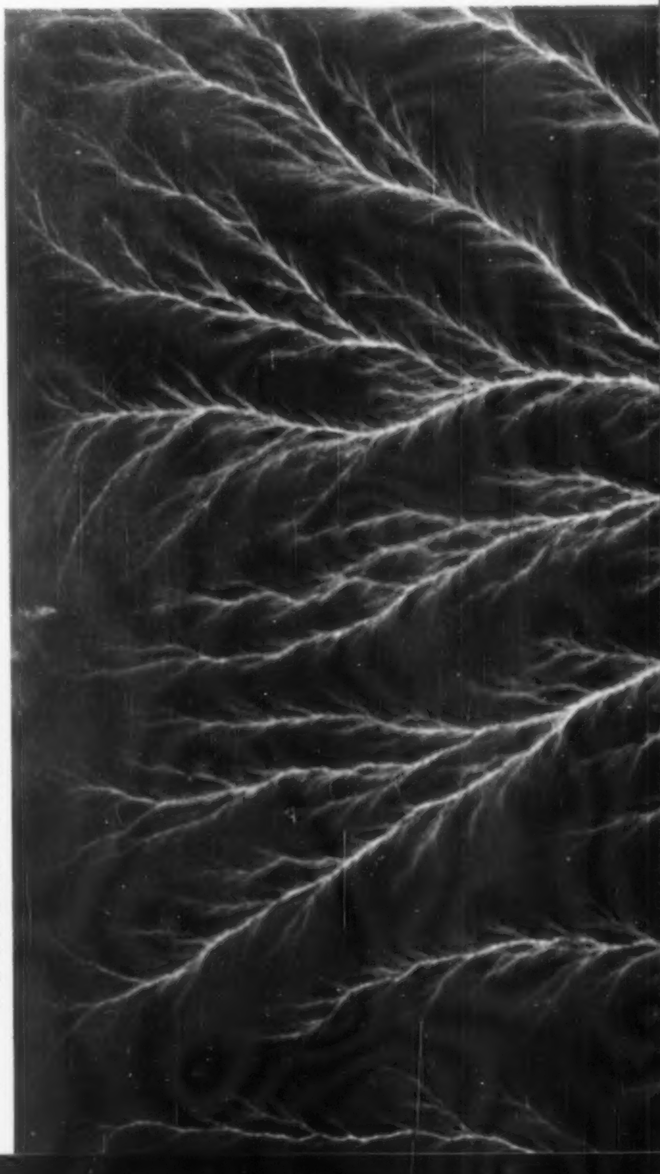
Of course, no corporation would justify its research program merely on the basis of what the investor might want. But by a not-too-surprising coincidence, the largest and best-organized research programs seem to produce an annual return year after year that excites not only management but everyone interested in the future outlook for the corporation.

After money...where to start?

Most chemical firms today have been conducting research in one form or another for decades. They have had time to start from a simple base of operations and build their research program over a long period of time. They have had time to try research methods from an "Edisonian" approach which finally has culminated in a system that fits their needs and budgets.

But how can a company that has decided to enter the chemical industry in the past decade decide to do research? The problem is akin to the chicken-egg cliché. If a company decides to organize a research program first and then get into production based on the results of its work, it probably would take years to return one dollar of profit. Such an ambitious program also would consume a large reserve of capital. While it certainly is a possible approach for gaining a foothold in chemicals, or any other field for that matter, it produces a sizeable number of problems.

One is that any product goal se-



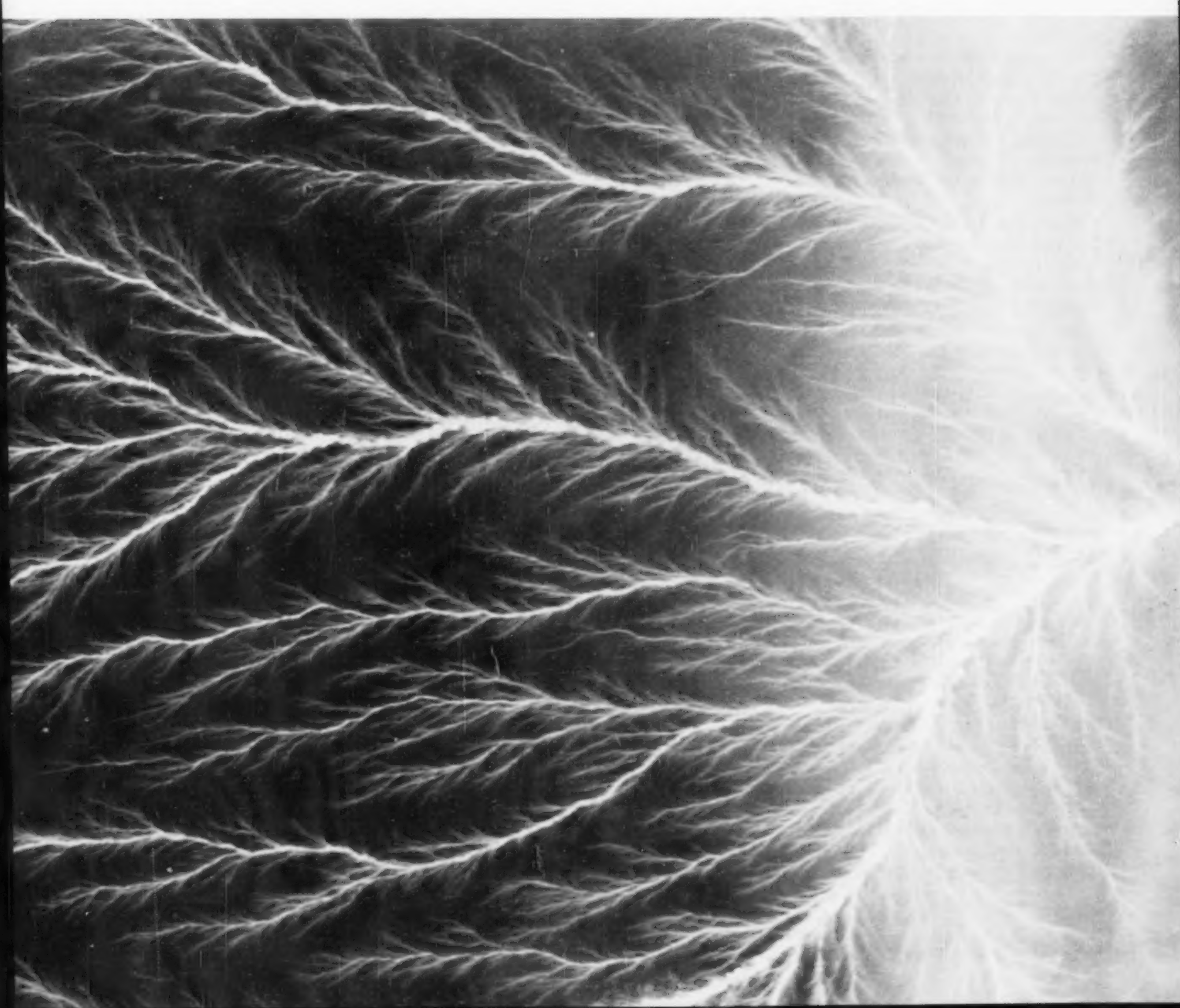
'FROZEN LIGHTNING' *photo was made at the Grace radiation lab in Washington by charging plexiglas with two-million volts. The lightning-like effect is created when the charge is grounded and the electricity runs to the grounded point.*

Photograph by Peter Pruyn

No newcomer to organizing chemical research activities, William P. Gage—
vice-president and director of W. R. Grace & Co. and president of the company's research division—
was manager of R&D for Shell Oil Co. and later vice-president of manufacturing for Shell Chemical Co.
At Shell he became experienced in the cold acid and other separation processes
and catalytic dehydrogenation later used in government butadiene plants.
He directed the design and operation of the butadiene plant at Torrance, Calif.
and also helped design a similar plant at Lake Charles, La.
Gage received his BS in chemical engineering
and MS in petroleum engineering at the University of Oklahoma.



by **William P. Gage,** *president W. R. Grace & Co. Research Division*



Selling and producing a chemical before research facilities were established gave an essentially non-chemical company the entrance it needed. The experience provided the basis of a large R&D effort to come.

lected would suffer from the competition of companies in the same field which already have a well-organized program underway. Thus, if a company decides to research itself into polymer chemistry it would be up against all of the polymer-producing companies already making products and gaining new knowledge and direction from day-to-day contact with product users. While it might not be hopeless to start from scratch and attempt to come up with a "better mousetrap" than dozens of successful competitors, it most assuredly would be a long, hard road.

Produce first, then research

A better solution might be to decide first the areas in which the chemical field seems most promising and then select processes in these areas that are available on an outright purchase of knowledge. The premise here is to buy the research and production know-how and get started with a plant that will produce a marketable chemical product.

While one team is licking production and sales problems, another team—the embryonic research team—can begin thinking about the future. The approach seems more practical.

How a company might enter the chemical industry as well as achieve the proper direction in research, product development, and manufacturing, may be illustrated by the "research headstart" of W. R. Grace & Co. in the chemical field. The story involves the recent transition of the House of Grace from a steamship company with import, export, and Latin American manufacturing interests to a major chemical company.

In 1945 the net fixed assets of the firm were 61% in the steamship business; 32% in Latin American industrial and commercial activities; and 7% in various domestic businesses in the United States, in addition to interests in the Grace National Bank and Pan American Grace Airways.

There were two things wrong with the picture. One was that while we were thoroughly and soundly diversified in Latin America, we lacked participation in growth industries in the United States, which after all is a pretty good country to do business in.

Study after study after . . .

In examining a field for diversification, we inaugurated studies that seemed endless. We looked at everything, put our best people on the job, hired new talent, and met with consultants. The consensus was that the greatest growth potential lay in the United States chemical industry.

In 1952, after deciding to enter the chemical industry, we set up a commercial chemical development department. We hired engineers, chemists, market researchers, economists, and financial analysts, and categorized the entire chemical industry by breaking it down into segments.

It soon became apparent that it was far easier to identify the attractive segments of the chemical industry than it was to find an avenue of entrance. We did not have a sufficiently large industrial enterprise in the United States, and thus lacked a logical base for the kind of entry made by other diversified companies.

The competition's method

For example, we could not enter the way Armour & Co. did through the systematic upgrading of waste byproducts. We could not enter the way Koppers did — by devising a new-type coke oven which made available more of the byproducts of coal, and pointed to new areas of chemistry built upon petroleum, gas, and other basic products.

Neither could we emulate American Hard Rubber, whose case—in switching into plastics when new plastics were causing the gradual obsolescence of its basic product—is a fine example of dynamic planning.

Nor could we enter the chemical industry as the petroleum companies had by capitalizing on the chemical richness of their industry's byproducts; nor through the research genius which enabled the explosives companies (DuPont, Atlas, Hercules) to broaden the chemical base of their existing industry.

Alternative methods of entry into chemicals were:

- Acquire existing chemical companies.
- Construct plants based on the licensing of already-developed processes available through engineering companies.
- Initiate a large R&D organization and commercialize results therefrom.

Gradually it became apparent that no single alternative would suffice; a combination of all three formed the ground-work of the general plan. During the earlier years, the emphasis was to be on acquisitions. Then, as we developed a position in the chemical industry, the construction of new plants based on purchased processes would become practical. Eventually, the development of our own large research staff could form the major base for growth in the years ahead.

A textbook approach

Our people then began to study a variety of chemical opportunities. As these were screened further, a thorough analysis of profitability was made, using classical market, engineering, plant location, customer, and transportation studies, etc.

The studies were summarized in two sets of reports. The first was a preliminary report which covered everything the long report did, but with "guesstimates" supplied where details were lacking. Then, if the chemical was not eliminated because of its lack of profitability, a more extensive analysis was undertaken.

In effect, we studied everything that might be deemed a growth segment of the industry and the route was painstaking, severe, and time-consuming—even though we were anxious to get started.

Once we had reduced the various alternative investment possibilities to a dollars-and-cents evaluation, we were ready for the really difficult job of selection.

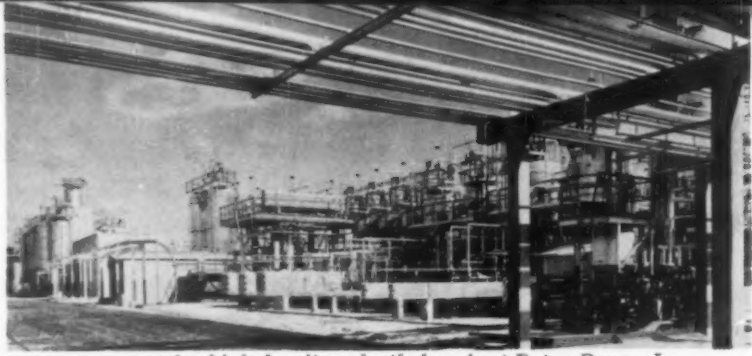
The best costs more

We found, of course, that the most attractive projects were the most expensive, in the sense that a good chemical company would join with us only on the basis of a high price-earnings ratio. Also, we found that almost any growing chemical product which could be entered by purchasing an available process would show only a modest profitability after competition began to intensify.

The profitability figures of the various alternatives had to be compromised with a realistic appraisal of what we thought we could handle.

There are too many magazines already. Time is my most precious commodity. Why waste it reading about other people's ideas? Only with money can I buy time. Why spend money for your magazine when I can use it to pay someone to get ideas. Besides, ideas are dime a dozen. Who needs them? All I lack is time . . . time . . . time . . . I am a busy executive. I administer engineering projects. I don't need ideas and I don't read Industrial Research. This way, I save $5 every year, or $9 every two years, or $13 every three years. My name is Vacuum.

Time is my most precious commodity. I can turn it into money, accomplishment, love, or happiness. All I need is an idea and a thousand sub-ideas. Anything that supplies me with workable ideas is worth money. I pay engineers tens of thousands of dollars a year to work out ideas. If Industrial Research gives me one workable idea it's well-worth the $5. If it gives me 100 ideas, I'll replace my engineers with it. My name is Progress.



NEW GRACE PLANT *for high-density polyethylene is at Baton Rouge, La.*

Some of the more glamorous projects had to be postponed until we had built up a chemical organization, so we had to settle for a more gradual stable entry into the industry.

In fact, when we decided to make ammonia and urea, we knew the venture would be only modestly profitable, but at least these products were practical from a technological standpoint. In effect, we were beginning with a growth segment of the industry where more profitable expansion could be undertaken once we had a plant underway.

We began in 1952 with the organization of the Grace Chemical Co., which was to build and operate an ammonia and urea plant at Memphis, and which constituted our research and development personnel, although up to this time we had no laboratories or research program other than the study and investigation of fields that showed growth opportunities and of chemical companies that would be attractive acquisitions.

Double merger

Later that year, Grace Chemical Co. licensed processes which enabled it to start construction of the ammonia and urea plant in Memphis, Tenn. During 1954 we merged with two widely known companies—Davison Chemical Co., prominent in inorganic chemicals, fertilizers, and catalysts, and Dewey & Almy Chemical Co., equally versed on the organic side in chemical specialties, complex polymeric compounds for container sealing, synthetic rubber latices, and polymers such as "Cryovac" film for packaging.

While we were getting acquainted with these acquisitions, we brought our Memphis plant on stream. Some time later Grace Chemical was split, the name being kept by the operating division and the R&D segment becoming the Grace Research & Development Division.

Subsequently, another decision of importance to Grace's Chemical future was taken. This was to enter the field of bulk polymers, particularly polyolefins. As the first step, a license was taken from Phillips for high-density polyethylene, and construction was started on a plant at Baton Rouge, La.

The decision naturally had a profound effect on our research laboratory. While the polyethylene plant was being built, another operating division, known as Polymer Chemicals Division, was split off to carry on the bulk polymer segment of our chemical business.

Our early thoughts on research are ambitious in retrospect. Can you imagine a management trying to decide on a research budget amounting to millions of dollars, when before 1950, it had never authorized a plant costing more than $2-million? Educating a non-technical management to the idea that it must spend millions on its research thinking is a story in itself.

It wasn't until Grace had acquired two chemical companies with long years of experience in research programs of their own that any real headway was made.

Why central research?

Perhaps one of the strongest breakthroughs in the concept of why we should have central research is embodied in a memo presented to the Grace top management late in 1954:

"Eventually we will need a central laboratory to do exploratory research in new fields not already exploited by one of the operating divisions. This laboratory must be free from the daily pressures of the operating groups which frequently are too concerned with today's problems to have much sympathy with tomorrow's dreams.

"If we are going to go after the maximum dollar return on our research investment, we will have to do more than rely on growth by methods such as expansion of present or allied product lines, or buying the know-how for 'standard' processes; or purchase of established chemical companies. It also will be necessary to develop new products or processes, or to acquire

them while they are still in an unproven stage.

"If this new group is to get a good start in the company it must come to a job where it can make a tangible, creative, contribution. We can't bring in qualified technical people and just let them mill around."

The function of the central research laboratory, as formulated five years ago, was to serve as:

- A long-range research group, concentrating in fields believed to be attractive to the company.
- A centralized service facility for divisions of the company.
- A technical consulting group to the Grace management, suggesting possible new developments that might be profitable and aiding management in the technical aspects of its decisions.

The laboratory would do research for the company divisions on a contract or annual budget basis if requested.

100-million dollars later

By this time management had added not only some $100-million in chemical assets but, equally as important, had added men of chemical stature to its board to help round out the newly emerging chemical image.

The next move was to find a site for the central research facilities. The location should be an area that would allow for detached creative thinking and yet be convenient enough to the cultural and educational advantages of a city. We soon found that every director is an expert on where to put a research laboratory, and I'm sure we could publish a book on "Finding the Ideal Location."

While location-hunting was going on, the Davison Division was building its new research facilities near Clarksville, Md., which is located less than an hour by car from either Baltimore or Washington. The Davison management then made us an offer. Davison would be willing to turn over the new laboratory and all personnel to the Grace Research Division, and then contract with it for all future research. The site had ample acreage for expansion and for the new central research laboratory.

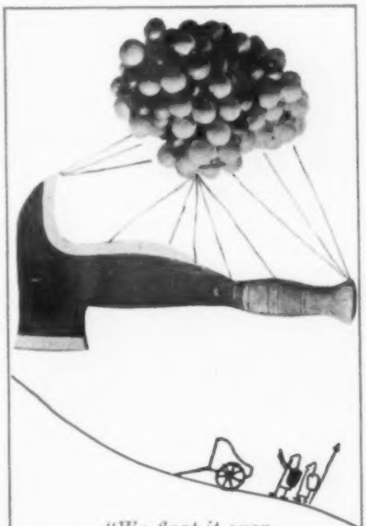
In a matter of days the idea was approved and the plan executed. During 1957, while the inorganic, catalyst, and agricultural chemicals laboratory was being completed, construction was started on an adjacent laboratory which would house the organic, polymer, and research services groups. Today we have more than $6-million invested in these facilities.

We have been in operation with the present facilities and people for more than a year at our Washington Research Center, and the first building will be two years old in Spring. During this time, our research organization thinking has matured rapidly. The Central Research Division recently has been given cognizance over the research conducted by the divisions themselves, which is largely applied and fairly short-term and within the fields of activity of the divisions or closely allied fields. To be sure that the best research skills and equipment are applied to all problems within Grace we have an active research committee made up of the research directors of all divisions.

Research for profit

The experience has taught us that specific research objectives should sustain and extend the present business of the company. Industrial research should be done, simply, to maintain and improve the profit-making ability of a company.

The chemical industry is fast-moving and intensely competitive. When a company enjoys an unusually favorable position with a product, it immediately becomes the envy of potential competitors who either initiate new research or intensify old research, seeking a share of the attractive business. Because of this competitive situation, every successful firm must devote a substantial part of available research resources *merely to maintain* current profits relative to competitors.



"We float it over the enemy lines, then we pop the balloons with slings."

This involves not only spending money, but frequent re-evaluation of the technical foundation upon which the current business exists. Research for the benefit of existing products must cover every aspect of producing and selling the product. Raw material, quality and prices, shipping costs, plant investment and obsolescence, efficiency of operation, and product quality are but a few of the critical, constantly changing aspects.

But no matter what the objectives may be, its outcome depends to a large extent on the creativity of the men who do the research. Herein was Grace & Co.'s research headstart. When Grace Research assumed the laboratories of the Davison Division it already had built up a program over the years based on the needs and objectives of Davison itself.

Researchers should hire researchers

In building a staff for the organic and polymer research program, men with years of experience in this field were chosen. The selection of these men was left to the research directors themselves rather than to a personnel department. It takes a top research man to interview and hire a top research man.

The outcome of all of this is that Grace has expanded rapidly into the chemical industry. Fixed assets at the end of 1958 were 49.2% in the chemical business — only a gleam in management's eye seven years earlier; 23.2% in the steamship business in contrast to 61% some 13 years earlier; 19.3% in foreign business including Latin American paper and chemicals, contrasted with 32% from the 1945 figures; while our general U.S. business is up 1.3% from the 7% of 1945.

While 23% in steamships compared with 61% seems much lower, actually 23% today is a net increase of $31½-million in assets over 1945, or one and a half times as much. The same is true of our foreign business. Actually, the investment is up about 300% over 1945.

An education

Grace's chemical investments have amounted to an education in the appropriate size and scope of an adequate research organization and budget.

This year Grace's budget is more than $9-million for central and divisional research. The figure includes market research and general market studies, technical service, capitalizable engineering, quality control, and product testing.

The research story of Grace is not over, of course, but it has reached an initial point of success. Success in research depends on many factors, but as some wise man once said, "You can't beat a man with a plan." ■

DE-SALTING SALT WATER

by **K. M. Wylie Jr.,** *I•R contributing editor*

CONVERSION *of salt water to fresh is no longer a mere dream. Installation above, at Aruba Netherlands Antilles in Caribbean, is not only world's largest conversion plant (2.7-million gals. per day), but also is first to combine desalting process with electric-power generation (15,000 kw). In aerial view, right, distilled water trickles over crushed coral (in top rectangular building) before spilling into tanks to restore full flavor and counteract acidity. Below, early attempts included "Captain Chapman's simple contrivance" in mid-18th century. "Contrivance" was used aboard ship to yield two quarts fresh water per hour.*

WHEN THE TERRIBLE DROUGHTS of 1932-36 made a dust bowl of much of North America's Great Plains area, thousands of farmers from the scorched, ruined land flooded westward. They were going to a green, water-saturated oasis called California, saying perhaps with Ma Joad in John Steinbeck's novel, *The Grapes of Wrath,* " . . . it'd be nice under the trees, workin' in the shade." Today it is estimated that southern California itself has only enough water left in its present sources to last about 18 years.

California's water problem in many ways typifies the world's water problems today, a strange if traditional quirk in the quartermastery of the earth — plenty of supplies but in the wrong place. There is ample water for the earth's approximate population of 2.75-billion, but it isn't distributed equally. About a third of all land areas on the globe are arid. Drought, ranging from slight to serious, is common for example, in nearly all of California's agricultural areas.

There are generally two ways to

solve the water-shortage problem, either de-salt sea water and brackish (heavily mineralized) groundwater, or move, re-channel, husband, horde, re-circulate — conserve — the fresh water we already have.

California is attacking its present and impending water shortages with both methods. At the University of California, Dr. Leroy Bromley, professor of chemical engineering, has developed a method for de-salination called the multiple-effect centrifugal evaporation system which gives hope of converting salt water to fresh at the lowest cost of any equipment so far, 25 to 50 cents per thousand gals.

Also at California, experimental work has been done on a de-salting technique called low-temperature-difference distillation. By using the heat from the waste warm water of an industrial plant (an application of the conservation approach for obtaining water), California's researchers feel they could turn out freshened water at about the same maximum price now paid for urban water supplies.

Another application of the conservation technique is California's immense Feather River project, to cost $2 billion or more. Its function: to bring water from aqueous northern California down some 250 miles through a system of aqueducts to southern California. While this lower third of the state needs 77% of its total water supply it can contribute only 2% from its own water resources.

Large-scale conversion

Large-scale conversion of sea to fresh water no longer is limited to the mere planning stage. Half a million people in various parts of the world now are living on 12-million gals. of converted salt water daily. Just 10 years ago only 2-million gals. a day were being converted.

Aruba island in the Netherlands Antilles boasts the world's largest salt-water conversion plant—a $10-million installation which produces 15,000 kilowatts of electric power and turns out 2.7-million gals. of de-salted water daily by a process called multiple-effect distillation.

In the Shiekdom of Kuwait is the largest flash-distillation plant in the world, the second biggest of all de-salting plants. At a daily output of 2.5-million gals. its production is only 200,000 gals. less than Aruba's.

At this stage of salt-water-conversion research and water conservation the important matter is not so much the volume of water being processed. It is how much progress is being made in developing workable techniques for de-salting and conservation, progress toward doing the job at a feasible price, and progress toward understanding the dynamics and evolutionary changes in man and his environment which are causing him to run out of water.

The wrong kind of water

World-wide precipitation averages about 20 in. annually; yet almost a third of the world gets only 10 in. or less. Not only is water poorly distributed, but most of it is the wrong kind, that is, the 75% of the globe covered by salt water. Sea saltiness varies among different bodies of water; the Baltic Sea has 7,000 parts-per-million (ppm) of dissolved salts and Utah's Great Salt Lake has at least 210,000 ppm. Average ocean salinity for all seas is 35,000 ppm.

Fresh water is also short in other areas besides coastal regions. Much of the water in lakes, rivers, and wells is brackish — less salty than ocean water but containing more than 1,000 ppm of salt. The groundwater that runs down to a depth of 15,000 ft. in the earth's rocky crust is the same type.

Water cannot be certified fit to drink, according to the U.S. Public Health Service, when it has more than 500 ppm (or 1,000 ppm if absolutely nothing else is available). Nor is it simply a drinking problem. Water for agricultural uses such as irrigation should not exceed 1,200 ppm.

Also many areas that once tolerated mineral-loaded waters no longer will do so, either because individual users have grown more discriminating or because industrial needs prohibit it. As civilization pushes out into new areas, the story of parched cities and water emergencies becomes more and more familiar.

500 miles to laundry

At the new hotel in Hassi Messaoud in Algeria's northeastern desert country, water is so scarce that the laun-

dry is sent 500 miles to Algiers. Several years ago, in southeastern Australia (the world's driest continent), 14 trains of 10 tank cars each made one round trip daily carrying water to the drought-stricken city of Broken Hill.

In the United States, rainfall averages 30 in. a year, or nearly 10 million gals. for every person in the country. Yet many western areas lack water because of poor distribution. Now, even the East's plentiful supply is changing.

The change indicates the *overall* water-shortage problem in the U.S., that is, post-WWII droughts east of the Mississippi coupled with swelling water consumption. During New York City's famed drought of 1949-50, water consumption fell from 1,172-million gals. daily to 953.3-million gals. Even in metropolitan Chicago, sprawled alongside Lake Michigan (23,000 square miles), suburban wells now must be sunk to an unprecedented 21,000 ft. in search of water.

One form of swelled consumption is the huge spread of irrigation east of the Mississippi Valley. Nine years ago in Indiana irrigated farm acreage totaled 5,000; now the state has more than 25,000, and by 1965 it is expected to have 80,000.

Since 1900 the United States has boosted its water usage from about 40-billion gals. a day to more than 240-billion, raising daily per capita use from 530 to 1,500 gals. Those figures include *all* water consumed, not only *by* individuals but also *for* them in agriculture, industry, municipal service, etc. Average daily water use by individuals is estimated at about 90 gals. for 1900 compared to nearly 150 today. (Science estimates we *need* to use only about 20 gals. a day apiece.)

By 1975 the U.S. will be using twice as much water as today, and by 1980 600-billion gals. of water daily.

Congress' salt water act

Out of such problems grew the saline water act of July 3, 1952 and the Office of Saline Water.

The Congressional group most immediately concerned with the saline water program, the House Public Works and Resources Subcommittee of the Committee on Government Operations, plainly has realized the seriousness of the water problem. The committee's latest report states:

"Unless bold and concerted action is taken, the United States, within the next generation, will face economic retardation to an almost catastrophic degree."

Congress' main goal is a practical, low-cost method for making salt and brackish water fresh. Originally (in 1953) the cost goals for municipal water were set at 38 cents a thousand gals. and for agricultural irrigation water, at 12 cents. Later the OSW revised its figures for various conversion methods to a range of 27 cents a 1,000 to $2.30. The job of reaching these cost goals is in the hands of various industrial and research organizations, universities, and individual scientists.

De-salting methods now being studied include various thermal, mechanical, chemical, and electrical methods.

One principle is common to all of them: sea and brackish waters consist of salts dissolved in a base water. De-salting water, then, consists of separating these water molecules and salt ions. This separation takes thermodynamic energy, as much as it took to join, that is, dissolve, the salt and water in the first place.

The salt still

Distillation is one of the oldest methods of de-salting water. At this point in de-salting research distillation seems to promise most for the future because it's the most economical.

Dr. Bromley's multiple-effect centrifugal evaporation system is still in the development stage, but apparently it could be more economical than other systems because of its compact size and use of operating heat.

Each of the units is 10 ft. in diameter and about 12 ft. tall. Its daily output of 100,000 to 200,000 gals. of demineralized water is made at the rate of 20 to 50 lbs. of fresh water for each pound of steam used. A battery of units, freshening 10 million gals. daily, could reach the low 25-to-50-cent cost figure.

Sea water is piped into the unit from the top and distributed over the upper surfaces of trays, mounted in tiers on a steam turbine. In each evaporator unit are six stacks of 20 to 50 trays. While the trays spin, sea water spreads across them from above. Steam sent in below the trays rises through the tiers and vaporizes the thin salt-water film on each tray's upper surfaces. This fresh water vapor rises, clings to the bottom of the next tray above, then runs off into a trap.

Multiple-effect distillation is probably the most highly developed of all salt-water conversion methods. In this method, the type used at Aruba, salt water is freshened in a series of evaporators, or "effects." The object is to make the greatest use of the energy used to boil the water.

Steam is piped into a submerged coil in the first effect's feed water, the strongest brine in the system. Feed water may be held at atmospheric (or slightly higher) pressure in this effect. The salt water boils off in steam (fresh water) passing through pipes into another coil in the next effect, where salt concentration is lower. Boiling temperature rises with an increased concentration of salt and vice versa and so this steam from the first effect is hot enough to boil off the second effect's salt water. Also vacuum pumps may be used on these following evaporators, to help lower the boiling point.

When its heat is released to the second effect's salt water, the steam in the coil condenses to liquid fresh water and is piped into a main storage tank. Steam from the second evaporator's boiling salt water flows into the coil, which is submerged in the third effect. Then the process has begun.

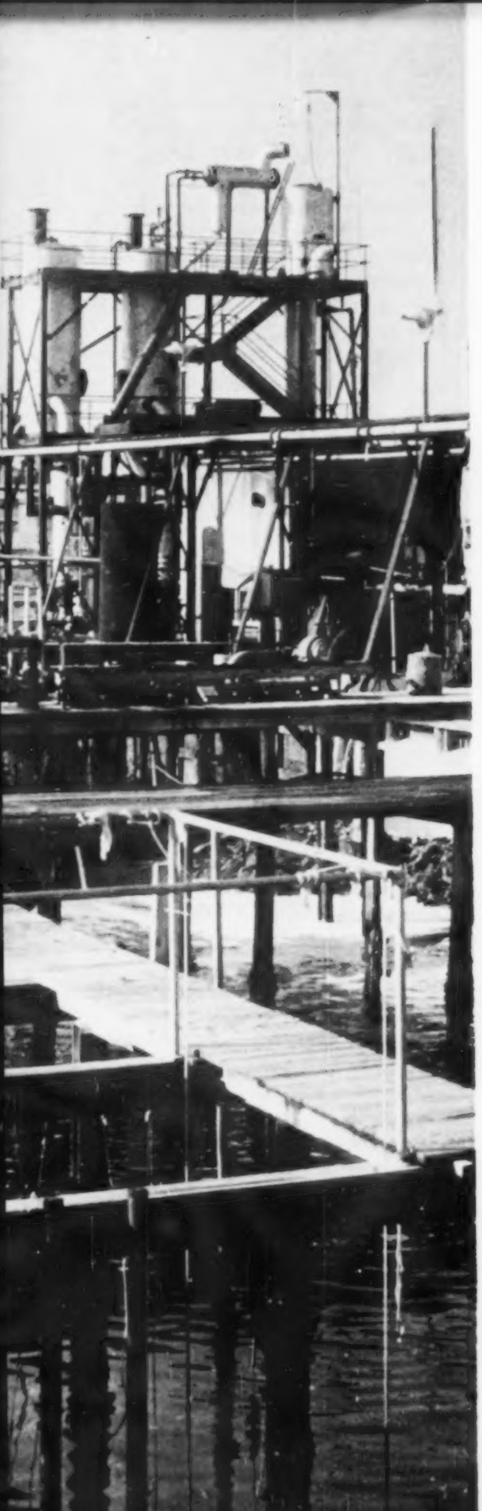
In theory, at least, the larger the number of effects, the cheaper the final product, since more fresh water is being wrung out of the original boiler. Some researchers believe that with as many as 20 effects, for example, a multiple-effect installation could turn out water at the OSW's ideal price of 30 to 40 cents a thousand gals. In practice, though, such a big plant might not be so efficient.

Fresh water and electricity

In this connection, one of the big reasons for selecting the submerged-coil multiple-effect distillation method for Aruba was that it made it possible to combine 15,000-kilowatt turbogenerator power plant with the boiler system. Aruba needed both water and electricity to supply present needs and attract more industries and tourists.

The plant's designers felt that this duality of fresh water and marketable electricity is the biggest hope for bringing reduced water costs into the world's water-poor regions.

The multi-stage long vertical tube evaporator built by the W. L. Badger-Whiting Corp. is another approach to



INTERNATIONAL NICKEL'S *Harbor Island lab near Wilmington, N. C., includes a multi-stage long vertical-tube evaporation plant and (not shown) a rotary compression still.*

the multiple-effect system. Steam goes from evaporator to evaporator through tubes. Vacuum pumps lower the air pressure slightly in each successive stage to drop boiling temperature. Developers of this method believe that with good scale control, it might de-salt water at about 40 cents a thousand gallons.

Flash distillation

Still another variation of the multiple-effect method is *flash distillation.* In this system feed water is heated almost to its boiling temperature, then piped into a vacuum chamber where pressure has been dropped below boiling-point pressure. It flashes to vapor and condenses as fresh water.

Advantages of this system are that water scale doesn't form in the processing equipment since the water is not boiled. Also, because lower-temperature water can be used, it's good for making maximum use of waste heat around industrial plants and ships. One big disadvantage is that since flash-evaporation concentrates saline water by only 10%, compared to 50% for straight boiling, more salt water has to be pumped, piped, and processed to cook out an equal amount of fresh. Thus, more expensive pumps, more heat, and longer processing time are required.

The big flash-distillation plant at Kuwait processes the Persian Gulf's rank salt water to fresh at a (reported) cost of about 63 cents a thousand gals. Fuel is free natural gas that would be wasted otherwise. Plant builder was Westinghouse Electric International Co., New York.

The *low-temperature-difference distillation* process researched at the University of California has been put into operation at Abidjan, Africa. The process functions on the principle that power can be developed in any system where there is even a small temperature differential.

In California's experimental work, sea water at 90 F is sprayed into a dome-shaped vacuum evaporator chamber. About 5% of it evaporates and expands through a steam turbine on its way to a condenser where it is liquified to fresh water. The other 95% of the feed water drains off as waste brine, about five degrees cooler than inlet water. Output of this experimental plant is about 10,000 gals. a day.

California scientists working on the project believe the turbine might be made to run the unit's pumps, making the whole installation self-powered. Further, by using waste warm water from an industrial plant plus cold surface water from the ocean, they feel they could turn out distilled water at about the same top price now paid for municipal supplies—with an output of 2- to 4-million gals. a day.

At the African plant, warm water is piped in from the ocean surface; cold water is brought up from depths of about 1,500 ft. The temperature differential may exceed 35 F. California's scientists have been coordinating their work with French scientists who have been working on thermal-difference since the 1920s.

Pressure distillation

In *critical-pressure distillation*, salt water is put under a high pressure of about 3,200 psi and heated to about 7000F. It is then in a critical condition, and will vaporize when the slightest additional energy (heat or pressure) is applied to it. Although the *original* heat-energy expenditure is large, most of it can be recovered by heat exchangers. The biggest shortcoming is severe scaling and corrosion caused by the intense heat.

Compression distillation is based on the principle that compressing steam raises its temperature. The steam from boiling salt water is compressed until it is about 10 F hotter than when first evaporated. Piped back to the evaporator, it condenses to fresh water, releases heat, and boils more water without further heat.

Tho rotary compression drum still or centrifugal molecular still, invented by Kenneth C. D. Hickman and developed in collaboration with Badger Manufacturing Co., is an ingenious variation of the compression system. Its big advantage is a higher rate of heat transfer, as in standard compression distillation methods.

Salt water at a mere 125 F is sprayed on the inner surface of a rotating drum. Centrifugal force spreads out the water in a thin, turbulent film on the drum's inner surface. Part of this film evaporates and is collected as fresh water. Part of it is sucked out in the form of steam through the drum's bottom by a blower compressor and duct into the still's compartment surrounding the spinning drum. Distilled water, condensed from these vapors, is piped away.

Solar distillation

Solar distillation is a promising method of salt-water conversion. Basically the system is simple evaporation. Yet there is a difference. The sun's heat must be trapped for maximum use of its energy. The major shortcoming of solar stills is that they do not use the available sunlight efficiently. Their efficiency (on earth) varies from zero at sunrise to a maximum figure around noon, then drops to nothing again at sunset.

In a standard solar still, sunlight shines through a transparent canopy into the unit's black trays, loaded with salt water. These trays absorb sunlight and re-emit invisible infra-red rays. As in a greenhouse, the radiation can't pass back through the canopy and stays inside the still, raising its temperature. As the inside temperature increases, water evaporates and condenses, leaving salt in the trays.

How well does the system work? In one University of California test installation, year-round average production rate is about 1/15 gallon a day for each square foot.

Several methods have been tried to increase the efficiency of solar methods:

- Dr. George O. G. Lof, Denver, a consulting engineer, uses soil to hold the sun's heat, setting his still on the ground and transmitting the solar heat absorbed by the water directly to the ground surface. Even when the sun is not shining, the soil holds the heat, continuing to distill water. Efficiency estimates for this type of solar still are: one-fifth gal. a day for each square foot of still area, costing about 50 cents a thousand gals.
- One of the world's outstanding leaders in solar-still research is Prof. Maria Telkes of New York University. One of her experimental units, a 10-stage still, consists of sandwiched layers of alternating absorbing and condensing material. Each square foot of exposed area distills five or six times as much water as the same area in a single-stage solar unit.

Distillation researchers also have considered atomic power as an alternate to conventional boiler fuels, but studies have shown that a reactor probably couldn't be used practically for a plant converting less than 10-million gals. daily — much larger than today's biggest plants, at Aruba.

Heat is not the only form of energy and stills are not the only equipment which can convert fresh water to salt water. Various membrane processes seem especially well suited to sweetening less salty or brackish waters.

Moving ions

A direct-current charge sent through two electrodes supplies the separating energy in the *electric-membrane* or *electrodialysis* process. In the electrodialysis system, the negative chlorine ions move toward the positive electrode (anode) at one end of the unit, and the positive sodium ions move to the negative electrode (cathode) at the other.

Salt water flows in to the ion-transfer unit's series of compartments, which are separated by plastic membranes, alternating between sheets permeable to positive ions and those which will pass negative ones. Saline water grows more and more concentrated in the alternate compartments, and the water in intervening compartments is freshened.

One of the biggest electrodialysis installations is on Bahrein Island in the Persian Gulf. Its multiple banks of electrolytic cell demineralizers purify 90,000 gals. of fresh water daily.

The high-current use of the electrical-membrane method has made it too expensive for converting pure salt water. But it can do a reasonably economical job on brackish waters. For example, working for the biggest gold-mining interests in Africa's Orange Free State, scientists of South Africa's Council for Scientific and Industrial Research are building the biggest membrane-type converter to date. It will purify three million gallons of brackish water a day (300,000 more than Aruba) at a projected cost of 35 cents a thousand gals.

In fuel-scarce areas the *osmionic process* developed by Dr. George W. Murphy, University of Oklahoma, should be a boon. Strong brine supplies the energy in this process, named for its use of both osmotic and ionic forces.

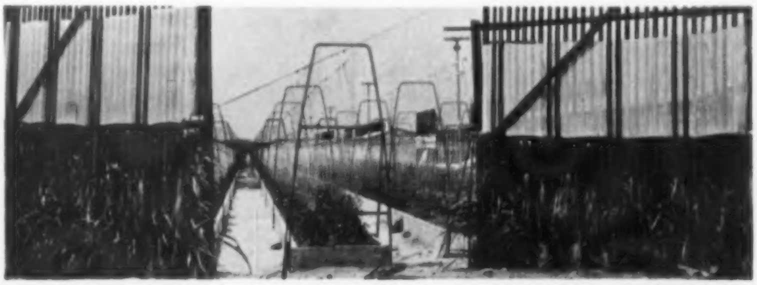
Positive ions force their way from the brine into a right-hand compartment, and that compartment becomes positively charged. Negative brine ions push through the membrane into a left compartment, which then is charged negatively. As the positive ions in the *center* compartment move toward their opposite charge, and vice versa, the center water is freshened.

Reverse osmosis is an experimental membrane process which makes use of the natural osmotic movement of a less-concentrated fluid through a membrane to a more concentrated one.

Freezing it out

Economy is said to be one of the big advantages of *freezing* methods for converting saline waters. Turning salt water to slush takes much less energy than boiling it. At about -6 F salt water freezes solid. Freezing methods capitalize on the state of the water just above that temperature. It is a slushy mixture of pure water crystals and brine. This freezing approach to conversion capitalizes on a process, known in metallurgy, called purification by crystallization—impurities (such as salt) have differing solubility in the liquid and solid states of a host material (such as water).

The goal in perfecting freezing conversion methods is a simple, fast, low-cost method for separating fresh-water crystals from the surrounding brine. Some of the most outstanding research on freezing has been done at the University of Minnesota's de-



12-ACRE HYDROPONICS FARM *(above) receives part of Aruba conversion plant's surplus fresh water. The island's 55,000 residents now get much of their fresh produce from these soil-less concrete troughs. Plant roots are in gravel beds fed by a mixture of chemical plant nutrients. At right, a rare old wood cut illustrates production of salt (and water byproduct) from wells in salt valley near Abingdon, Va., circa 1857.*

partment of mechanical engineering and the Navy's Civil Engineering Research and Evaluation Laboratory.

By packing flake ice in a piston and compressing it, for example, at 2,000 psi, they have been able to lower the salinity of ice from 35,500 ppm to 420 ppm.

Also at work on freezing methods, Carrier Corp. has developed a process combining freezing and evaporation for extracting de-salted water.

And at Batelle Memorial Institute, scientists have developed a method based, again, on a metallurgical process, zone refining. They freeze an ingot of ice: the top half contains salts and other impurities; the lower half does not. Using ultrasonic agitation to make ice ingots, they have delivered water at a low five ppm salinity.

Near Tel Aviv, Israel, a variation of the freezing process is being used in a new sea-water conversion plant to produce 250 gals. of fresh water an hour.

Liquid-liquid extraction

Solvent extraction of de-salted water has been referred to as liquid-liquid extraction since it consists of absorbing fresh water out of salt water with a solvent, then separating the solvent from the pure water.

Important work in this area has been done at Texas A&M's department of oceanography and meteorology. In its simplest terms, the process researched there consists of bringing solvent and sea water together at room temperaure. The solvent selectively extracts water, leaving a concentrated brine; the solvent-water extract is heated to separate the fresh water, the solvent is cooled to begin the cycle over again, and the water is cooled. Among the solvents used are such compounds as tertiary nonyl amine and N-ethyl-n-butyl amine.

Energy consumption is much on the minds of the Texas researchers. One of their aims in developing the ideal solvent-de-salting process cycle is to approach a reverse transfer of energy. If they could achieve this, energy input and use largely would be contained within the system. While they realize that full reversibility probably isn't possible, it is a good basis for comparing salt-water conversion methods as well as a good long target to aim at in shooting for the greatest possible efficiency.

Although the water-conservation techniques now available are less highly systemized or mechanized than the de-salting methods, they may be the immediate means for keeping the mains and reservoirs full. Both industry and government are at work on methods for getting the most value out of available water.

Covering reservoirs

Stopping or slowing evaporation from small reservoirs by spreading thin, molecular films of anti-evaporative chemicals such as hexadecanol over them would save millions of acre-feet of water annually. While these films have not been successful on larger water bodies because of wind effects, the goal of mitigating evaporation seems so reasonable and necessary that it is a tempting one.

Water statisticians say that in a single year evaporation in the 17 western states costs the U.S. more water than is pumped by all the municipal water systems in the country.

Clearing non-useful, water-consuming vegetation out of source lakes, sewers, and reservoirs also helps to reduce water losses.

One of the most obvious ways to save water is to stop throwing it away. The techniques are manifold.

In Chicago, workers tracked down and patched 130 under-ground pipe leaks, saving 10.5 million gals. of water a day. And in Bensenville, Ill. a manufacturer, rightful winner of the prize for water penury, drains rain off five acres of factory roof plus five acres of parking lots, then stores it in two lagoons, treating it before use — all for about a half cent per thousand gals.

In this same economical vein, a Kaiser steel mill has lowered its water use from 65,000 gals. for each ton of steel produced to 1,500 gals. by recirculating plant water.

When engineers at California Oil Co.'s Perth Amboy (N.J.) refinery on Raritan Bay, just inland from the Atlantic, needed cooling water for the plant, they simply piped salt water ashore. When still more water was needed and the price of bringing in fresh water or more salt water from the primary source seemed too high, the engineers put up a cooling tower, recirculating and chilling the water.

A limit to reservoirs

Using probability mathematics hydrologists in the Department of the Interior's Geological Survey can analyze many of the nation's water-supply problems. So far, for example, they have concluded that "there is a limit to how much we will gain by building reservoirs on streams in certain areas." The Colorado river, survey mathematicians say, is an example of a river basin where water-storage may be reaching its practicable limit.

By contrast, other researchers, working for the Department of Agriculture, say their studies indicate that less than 5% of the rain running off

Three Lions

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rangelands in the U.S. Southwest ever reacher a point downstream where it can be used. Here, says the USDA, the solution very definitely consists of small storage reservoirs, underground reservoirs, and corrective vegetation.

Throughout the world, water problems multiply, change, grow more serious. According to the Office of Saline Water, the need at this time in solving the water problem is not principally for bigger salt-water conversion plants but for the basic research and pilot-plant research. Only with basic research into the problems of purifying water can we reach the scientific breakthrough which must come before we can *consistently* convert salt water for much less than 50 cents a thousand gals. and brackish water for less than 30 cents.

Already, though, some plants, research, and theories are functioning. Two Ionics Inc. electrodialysis plants are demineralizing brackish waters that lie as groundwater under the vast inland areas of this country — perhaps our next major source of water. At Redfield, S.D., a conversion plant turns out 65,000 gals. a day; one at Gettysburg Air Force Station produces 40,000 gals. On the arid west side of California's San Joaquin valley in the city of Coalinga (pop. 6,500) another Ionics plant, the country's first municipal de-salting plant turns out 28,000 gals of demineralized water daily.

At the same time proposals have been made for using atomic power to blast underground water reservoirs and to power pumps for filling the aqueducts of the Southwest.

Is the end in sight?

Yet once we have learned how to de-salt water, save it, (and bring it to deserts and towns, will that be the end of the water problem?

In Kensington, Pa. civil defense authorities have contracted with a local dairy to package enough quart cartons of deep-well water to supply the whole town if its surface water supply should be contaminated by radioactivity.

The United Nations' World Health Organization has taken on the improvement of the world's drinking water as one of its primary concerns. It points out, for example, that the building of new irrigation systems may cause the spread of a snail-borne parasitic infection, bilharziasis, unless precautions. . . ■

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